THE GLASS INDUSTRY
THE JOURNAL OF GLASS MANUFACTURING
VOLUME 42 NUMBER 10 OCTOBER, 1961

On Research

The demands on packaging materials become more severe every day, and with these demands, there is a continual need for stepping up the pace of research into the nature and use of those materials. This truth was highlighted last month when the Technical Center of Continental Can Company's packaging research complex—one of the largest in the United States—was officially opened in Chicago and Plainfield, Ill. The $20-million complex contains four major areas of research—the General Packaging Research and Development Laboratory, Metal Research and Development, Central Research and Engineering, and the Glass Research and Development Laboratory which is located in Plainfield, across the road from the Hazel-Atlas Glass Division plant. There are some 800 scientists and technicians at work here, and it is quite apparent that today's highly trained specialists have supplanted the physicist and chemist of yesterday: they are well versed in the techniques of such instruments as the electron microscope, X-ray fluorescent spectrograph, vacuum fusion analytical equipment for determining the gas content of glass, and the recording spectrophotometer for ultraviolet, visible and infrared spectra.

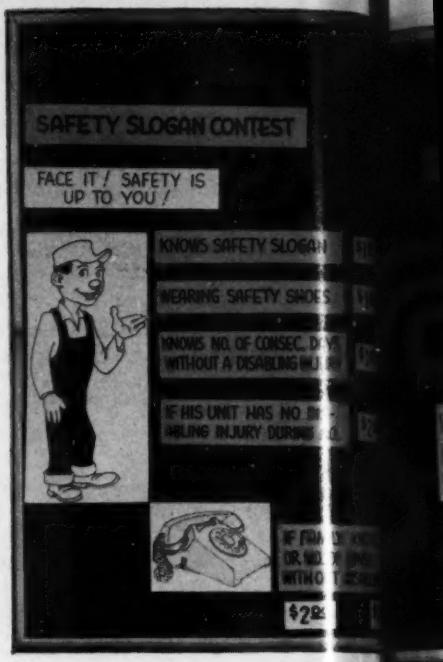
The very nature of these instruments has enabled scientists to intensify the tempo of packaging materials research (and glass research specifically) in the past few years. In this packaging complex, moreover, techniques used in the study of metals and other materials are applicable to study techniques in glass, and this fact lends itself to a cross-fertilization of ideas from department to department which accumulates along the way, resulting in added intellectual stimulation.

Some of the ideas coming out of the Glass Research and Development Laboratory have to do with inspecting hot glass before it goes through the lehr; varied colored plastic coatings which will protect the surface of the glass and exploit more of its natural strength; a coating for clear glass which approaches amber glass in ultraviolet protection; speeding up the removal of gases from molten glass; taking a close, questioning look at present-day forming machines (perhaps glass containers could be pressed out of a ribbon of glass, and the halves sealed together); more efficient furnaces that do not waste 85 per cent of their heat; new mold materials and specifications for castings of molds; and the study of heat transfer in glass forming—is the glass being chilled too much? Should the shape of the plunger be changed? The shape of the mold?

No one company, of course, has a corner on research, but the significant—even exciting—point here is that this packaging complex is representative of a fairly new attitude among glass companies across the land. Not too long ago there was a dangerous complacency in the glass community. Glass, an age-old material, had a certain reverence which, it was thought, would assure its prominence in packaging. Today, with competition among packaging materials keener than ever before, glass men, in order to maintain that prominence, must strengthen their research programs. That they are doing this is evident with each company announcement of new, or improved, research facilities in glass.

Because of this forward-looking attitude, the prospects for glass, not only in packaging, but also in construction, optics, space applications, electronics, and many other areas, are more favorable—and more challenging—than they have ever been before.

Many plant officials are complacent about the erroneously conceived "irreducible minimum" in safety records. Unfortunately, it is in this area that the more serious accidents often occur.



Is There a Marg P

by Clyde C. Rudd

There is no margin in plant safety. Anything above the absolute zero in an accident record can be reduced. This premise is generally accepted by plant officials, but there are many who can be lulled into a satisfied attitude if the plant accident record is comparatively good, *i.e.*, below other companies in the same industry or reasonably below a national industry average.

Being complacent about a fairly good accident record is a form of narcotic which brings on a paralysis of new ideas, not only among safety people, but within plant management as well. Too often the notion persists that adequate safety guidance is being provided, enough money is being spent, and the record is about as good as can be expected; therefore, "let's not go overboard in planning new programs when they probably won't show an improvement anyway." Or is it that human nature makes us reluctant to change what looks like a fairly good job?

Those industries which lead the national field with outstanding safety records would never remain leaders if their planning were inhibited by false minimum standards. Du Pont, U. S. Steel, and many others would not be proudly displaying, year after year, frequencies of less than one disabling injury for every million man-hours worked, if they did not keep emphasizing the importance of safety to management and employees. And once safety consciousness is achieved, these companies find it essential to keep developing new approaches to the problems involved.

It is possible that when you reach a point in accident records where you compare favorably with others, the remaining level will invariably include the more serious and costly injuries. Thus, you have eliminated only the minor cases which are, on the average, less costly and relatively easy to eliminate. If this is true, it is false economy not to increase the safety budget to eliminate those costly cases which occur in the erroneously conceived "irreducible minimum."

THAT EXTRA PUSH

That little something—that extra push—can take many forms. Management may be reluctant to increase the safety program, and it is up to the person responsible for safety to do a convincing selling job. This is the role in which many engineers fail. They are too prone to think that management is only giving lip service to safety, when lack of approval may be the result of a poor selling job. After all, there would not be a safety man on the job if management did not want a program. Several PPG plants, dissatisfied with a safety record that was just good, developed effective "attention getters" in the extra effort category. One outstanding example is the con-

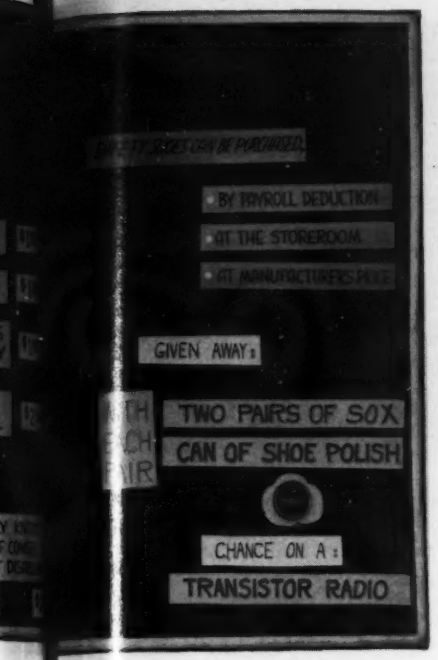


Fig. 1. Works 7 safety program designed to stimulate safety consciousness among employees and their families at Cumberland, Md.

Plant Safety?

of safety and plant
tion, Pittsburgh Plate Glass Co.

pany's Cumberland, Md., plate glass plant (Works 7). By careful detailed planning with the plant's executive safety policy committee, John J. Long, manager of safety and plant protection, developed a two-pronged program to supplement the highly-rated one already established there.

This 2-phase approach is summarized in Fig. 1 as a "slap on" presentation which was introduced to foremen and employees. The initial phase of the program included interest stimulators designed to arouse safety consciousness among both the employees and their families. All employees, whether hourly, salaried, or office workers, were given an opportunity, through a drawing, to win one or more cash prizes, provided that the employee *(1)* knew the plant slogan for the week, *(2)* knew the number of consecutive days that the plant had worked without a disabling injury (with an additional cash bonus awarded to the employee if his unit had no disabling injury during the previous month), and *(3)* was wearing shoes at the time his name was drawn. Simultaneously, the employee's home was contacted by telephone, whereupon the employee or any adult member of his immediate family was eligible for cash prizes for answering correctly questions regarding the plant's weekly safety slogan and the plant's consecutive record of days free from disabling accidents. If all questions were not answered correctly, the jackpot increased weekly until someone did win it. Sizeable amounts were accumulated and won, evoking much favorable comment within plant circles. There was no department where employees had not prominently displayed the safety slogan for reference. Can you imagine the impact at home if an employee failed to give his family the pertinent information needed to participate in the plant safety awards?

The second phase of this program acted to further stimulate safety practices by encouraging Cumberland plant employees to wear safety shoes. Furthermore, many employees purchased them for other family members to safeguard against miscellaneous accidents around the home, such as damaging foot injuries caused by power mowers. The plant's practices regarding safety shoes were so successful that they spread to five other company operations where they also achieved favorable results. Additional proof of the effectiveness of these programs is the fact that the employees, who have thus far worked one 280-day period without a disabling injury, are currently setting another record which has already surpassed the old one.

Within the company's widely-diversified operations, there have been many novel ideas implemented to stimulate safety practices. The following have been quite effective in reducing accident frequency.

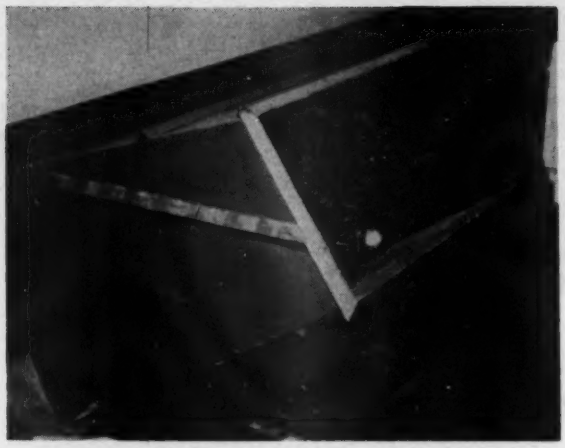


Fig. 2. Glass cullet hopper has been extended for added safety at both Works 3, Creighton, Pa., and Works 14, Mt. Zion, Ill.

Fig. 3. This loading device, designed for trucks and box cars, has been employed at Works 10, Henryetta, Okla. Note bracing of glass cases.

● A glass plant cullet hopper (Fig. 2) has been extended in two plants, Works 3 at Creigton, Pa., and Works 14 at Mt. Zion, Ill. Note that the extension of the hopper puts a lid on it to prevent flying glass (when it is tossed) and also increases capacity and decreases spills.

● Many signs have been erected inside and outside of company plants to remind employees of their part in the safety campaign.

● A device (Fig. 3) has been contrived by Works 10, a window glass plant in Henryetta, Okla., to keep heavy cases of glass from falling over while other cases are being loaded. This brace is used effectively in both trucks and box cars. Another window glass plant has raised one railroad track on its siding to prevent cases of glass from tipping over.

● An ordinary "A" truck has been equipped with end screens to prevent broken salvage pieces from tipping out. Slots in the end bar adjust the holding rods on each side of the "A" frame. Works 12 at Clarksburg, W. Va., developed the idea, and its application has prevented numerous serious injuries.

● A well-known fume-removing device is being used at Works 12 to take away the harmful silicon dioxide dust released when the surface of glass tank forms is dressed.

● Works 12 recently adopted a universal eye protection program. All employees, office and plant, are required to wear eye protection while in the plant. Considerable planning and promotion conditioned employees to the idea before the program was installed. A target date was set, meetings held, and literature, facts, and figures distributed to the employees and their families.

OFF-THE-JOB SAFETY

One of the invaluable "extra push" principles in accident prevention, is off-the-job (O-T-J) safety practices for employees while at home and on the highway. Company bulletin boards prominently display O-T-J posters

(*Continued on page* 597)

Fig. 4. Safety equipment, used by employees in the glass plant, on exhibit at the "Family Safety Fair", Works 7, Cumberland, Md.

One of the principal uses of lithium minerals and compounds is in the manufacture of special glasses and ceramics. The development, research, and potential of this element are discussed in the following report.

LITHIUM*

by Albert E. Schreck, Commodity Specialist, Branch of Nonmetallic Minerals, U. S. Department of the Interior, Bureau of Mines

Four minerals—spodumene, lepidolite, petalite, and amblygonite—are the important sources of lithium. The compound dilithium-sodium-phosphate (recovered from the brines of Searles Lake, Calif.) is the fifth important source. Principal domestic lithium resources are in the Kings Mountain area, N.C., Black Hills, S.Dak., and the brines of Searles Lake, Calif. Indicated and inferred reserves of lithium minerals and compounds are large.

Size, Organization, and Distribution of the Industry

The first substantial production of lithium was just before 1900 in the form of spodumene from the Etta Mine in the Black Hills, S. Dak. Additional deposits of lithium minerals were later developed in that area. A few years before World War II, a method for the recovery of coproduct dilithium-sodium-phosphate from the brines of Searles Lake, Calif., was developed, and by the end of the war this had become one of the most important sources of lithium raw materials. During this period an economic flotation process was developed for recovering spodumene from deposits in the Kings Mountain district of North Carolina[12].

Military requirements for lithium products during World War II resulted in enlargement of the production capacity of the industry. However, when government contracts were cancelled near the end of the war, producers were left with excess capacity because other markets of comparable size were not available. A few mines and plants continued to operate on a reduced scale; some were put in stand-by condition and others were abandoned. The remaining producers intensified their research and market development programs. As a result of this research, important new volume uses were developed and there was a multifold expansion of the market for lithium minerals and compounds after 1949. Shipments of lithium minerals from mines increased tenfold in the period 1949-54, and the industry has now reached the multimillion dollar category.

Four firms are currently the principal producers of lithium minerals and compounds. American Potash & Chemical Corp. recovers dilithium-sodium-phosphate as a coproduct from the brines of Searles Lake, Calif. This material is converted to lithium products in the company's plant at Trona, on the edge of the lake, and also in a chemical plant at Vernon, Calif. American Lithium Chemicals Inc. was formed by American Potash & Chemical Corp. and Bikita Minerals (Pvt.), Ltd. The plant at San Antonio, Tex., was completed about the end of 1955 to produce lithium chemicals from lepidolite from Southern Rhodesia. Bikita Minerals owns the Rhodesian property which is operated under the management of Selection Trust, Ltd., London.

Lithium Corp. of America produces lithium chemicals in a plant at Bessemer City, N.C., using spodumene concentrate produced by Quebec Lithium Corp. in Quebec, Canada. Lithium compounds and metal also are produced in the company plant at St. Louis Park near Minneapolis; however, these operations are to be consolidated at the Bessemer City operations. This firm formerly produced spodumene from several deposits in the Black Hills, but these operations were suspended in 1956. It also holds deposits of spodumene in the Kings Mountain district of North Carolina.

Maywood Chemical Works (a division of Stepan Chemical Co.) operates the Etta Mine in the Black Hills and purchases some spodumene from other producers. This spodumene is processed into lithium compounds and metal at the firm's plant at Maywood, N.J. Foote Mineral Co. produces spodumene in the Kings Mountain district of North Carolina. This material is processed into lithium compounds at Sunbright, Va., and Exton, Pa. In 1956 this firm began commercial production of lithium metal at Exton.

In addition to these firms there are a few smaller and intermittent lithium mineral producers in the Black Hills and in Maine. Metal Hydrides, Inc., Beverly, Mass., produces various complex lithium hydrides from the metal.

Grades and Specifications

Table I shows the approximate chemical composition and lithia (Li_2O) content of the commercial lithium minerals. Most consumers of spodumene for lithium chemical

*Originally published in Bulletin 585, Bureau of Mines, U. S. Department of the Interior

Lithium, the lightest of the metallic elements, has, in less than a decade, risen from obscurity to a period of spectacular growth.

production specify a minimum of about 4.5 per cent Li_2O. Certain glass and ceramic producers who use spodumene require a low content of iron or other coloring oxides. Lepidolite for use in glass should contain a minimum of about 3.5 per cent Li_2O.

TABLE I—Li_2O Content of Commercial Lithium Minerals

Mineral	Approximate Chemical Composition	Range in Commercial Mineral Percentage Lithia (Li_2O)
Spodumene	$LiAlSi_2O_6$	4 to 7
Lepidolite	$K_2Li_3Al_4Si_7O_{21}(OH, F)_3$	3 to 4
Amblygonite	$LiAlFPO_4$	8 to 9
Petalite	$LiAlSi_4O_{10}$	3.5 to 4
Dilithium-Sodium-Phosphate.	Li_2NaPO_4	19 to 21

Technology

The commercial sources of lithium minerals or compounds are pegmatite deposits, veins closely related to pegmatites, and brines. The bulk of the spodumene produced in the United States has come from the pegmatite deposits in the Black Hills of South Dakota and the Kings Mountain district of North Carolina[1, 2, 8, 10, 15].

The brines of Searles Lake, Calif., are the source of the compound dilithium-sodium-phosphate. This lake is a desert salt-pan or playa containing a body of crystalline salts having a depth of 60 to 90 ft. and an area of 30 sq. mi. The lithium content of these brines is approximately 70 parts per million or about 0.015 per cent Li_2O[6].

Pegmatite deposits which contain lithium minerals also occur in San Diego County, Calif. (amblygonite and lepidolite), Taos County, N.M. (lepidolite and spodumene)[16], Gunnison and Fremont Counties, Colo. (lepidolite), Fremont County, Wyo. (lepidolite, amblygonite, and petalite), White-Picacho district near Wickenburg, Ariz. (spodumene and amblygonite), and in areas of Maine, Massachusetts, and Connecticut. In several areas lithium is present in low concentrations in many brines, saline waters, and clays.

Lithium-bearing pegmatites occur in many countries. Important deposits of spodumene occur in the provinces of Quebec, Manitoba, Ontario, and along the north shore of Great Slave Lake in the Northwest Territories, Canada. Spodumene occurs in the great pegmatite dike at Manono in the Belgian Congo. Lepidolite, amblygonite, and petalite occur in pegmatites in several areas in Southern Africa. Numerous lithium-bearing pegmatites are known in Brazil, Spain, Argentina, Portugal, Sweden, Germany, France, and several other countries.

Mining, Milling, and Processing

Spodumene and other lithium minerals have been mined by conventional open-pit and underground methods, depending on the nature of the deposit. Spodumene has been recovered by hand picking (when the size of the crystals made this feasible), by sink-float, and by other methods, but the bulk of the spodumene is now recovered as a flotation concentrate.

The dilithium-sodium-phosphate is recovered at Searles Lake by treating the burkeite salt, which is the concentrate obtained after evaporation and subsequent separation of the brine, with a fatty acid derivative to which is added a light mineral oil. The dilithium-sodium-phosphate is floated by aeration and the resulting froth is filtered and dried[6].

Lithium compounds are processed from spodumene by one of two methods; one is an acid treatment, the other, an alkali treatment. In the first method, alpha spodumene is converted to beta spodumene by calcining at critical temperatures. Sulfuric acid is added and the mixture heated to form lithium sulfate. The lithium sulfate is leached from the mass, neutralized with limestone, and filtered. Soda ash is added to the aqueous solution of lithium sulfate to precipitate lithium carbonate. This is the basic material from which other compounds are derived. Calcium hydroxide is added to the lithium carbonate to form lithium hydroxide monohydrate. Lithium chloride is produced by reacting lithium carbonate with hydrochloric acid.

The second method involves stage-calcination of the spodumene with powdered limestone, and hydrolyzation with steam to produce a soluble lithium hydroxide. The lepidolite process consists of roasting the ore with limestone, and quenching and extracting the soluble alkali hydroxides. The solution of mixed hydroxides is concentrated, and lithium hydroxide monohydrate is recovered. To increase total lithium recovery, the liquor resulting from the filtration of the hydroxide is carbonated to precipitate remaining lithium as the carbonate.

Lithium metal is produced by electrolysis of a fused mixture of lithium chloride and another alkali salt, such as potassium chloride. Lithium hydride is produced by reacting hydrogen and lithium metal. The addition of ammonia to lithium hydride produces lithium amide.

Uses

Glass and Ceramics

One of the principal uses for lithium minerals and lithium compounds is in making special glasses and ceramics. Lithium carbonate and other lithium compounds form eutectics with alkaline oxides and with silica. This property is utilized in producing glasses, glazes, and enamels with high gloss and with scratch and chemical resistance. In these products lithium carbonate or other lithium compounds replace other carbonates in whole or in part, which keeps the alkali content to a minimum. In enamels, the addition of lithium compounds reduces the maturing temperature and increases

the fluidity of the enamel, thereby permitting it to be used on thinner steels and to be fired at lower temperatures. The acid resistance of such enamels is increased by the addition of lithium. Lithium compositions have displaced lead oxide to some extent in many glasses and glazes. Lepidolite reduces the viscosity and improves the workability of a glass melt, produces a hard surface, modifies the coefficient of expansion, increases the strength, and reduces the weight of glass. Such glasses are used in sealed-beam headlights for automobiles, trucks, and airplanes; in glass tubes for radio, television, and radar; in some neon-sign tubing, and in other special applications. Spodumene is used directly in some ceramic batches as a substitute for manufactured lithium compounds. Petalite is used in ceramics to control heat-shock resistance.

Lubricants

Another large use of lithium compounds is in lubricants. In this field some of the so-called "all-purpose greases" contain lithium stearate (or other soap) as the metallic soap component. These greases retain their lubricating properties through extremes of temperatures. They also have good water resistance and are used in military equipment such as artillery, aircraft, trucks, and automobiles, and in a wide range of nonmilitary industrial purposes. In greases, 1 lb. of lithium hydroxide monohydrate is used in 45 to 100 lb. of grease. The average composition of all the lithium-base greases, based on past consumption data, is about 1.5 per cent lithium hydroxide monohydrate.

Industrial Drying

Since lithium chloride is one of the most hygroscopic of inorganic compounds, a saturated solution will dry air, passed in contact with it, down to a very low humidity. In airconditioning and industrial drying systems, a solution of lithium chloride reduces humidity and also removes odors and dust from the air. Lithium bromide is used in gas-absorption type airconditioning.

Storage Batteries

Another important use for lithium compounds is in the Edison-type, nickel-iron alkaline storage battery. These batteries are used in electric industrial trucks, mine locomotives and shuttle cars, portable lighting outfits, power supplies for various devices such as chronographs, laboratory equipment, and seismographs, and also as stand-by power supply for elevators, engine stops, fire alarms, and railway signals. The positive plate of the cells of these batteries consists of a perforated nickle-steel tube containing nickel oxide and the nickel flake. The negative plate consists of finely divided iron oxide in nickeled-steel pockets. The container is made of nickeled steel with welded joints. The electrolyte is a solution of potassium hydroxide in water, to which a small quantity of lithium hydroxide monohydrate is added as a catalytic agent to increase the capacity and life of the cell.

Dry Cells

Lithium chloride or bromide is added to the electrolyte of some dry cell batteries enabling them to remain active at lower temperatures. Conventional zinc or ammonium chloride electrolyte dry cells become very inefficient at low temperatures and become almost completely inactive at about –20°F. At –40°F, dry cells containing lithium chloride can deliver about 10 per cent of the 70°F capacity (the standard rating temperature).

Miscellaneous Applications

Lithium fluoride and chloride are used as oxide scavengers and metal cleaners in welding or brazing aluminum and magnesium. Lithium metal has assumed importance in organic syntheses. It is used instead of magnesium in some Grignard reactions. Synthetic vitamin A is produced by processes utilizing lithium alkyls, and organic reactions of many types have been achieved with lithium hydride, lithium-aluminum hydride, and other lithium compounds.

Other uses for lithium and its compounds, which in aggregate account for only a small percentage of total consumption, include the preparation of dense oxygen-free high-conductivity copper, heat-treating metal, casting iron, and in cosmetics, medicinals, paints, waxes, and titania pigments. Metallic lithium is used as a catalyst in the preparation of synthetic rubber that resembles closely natural rubber.

The AEC revealed early in 1957 that it was purchasing, under contract, undisclosed quantities of lithium hydroxide. The Commission was extracting the lithium-6 isotope from the hydroxide. The residue (lithium hydroxide rich in lithium-7) was stockpiled and made available for repurchase by the suppliers. The exact use to which the lithium-6 isotope will be put was not announced.

By-Products and Relationships to Other Commodities

Lithium-bearing pegmatite deposits usually contain other potentially marketable mineral materials, such as feldspar, quartz, mica, columbite-tantalite, beryl, and monazite. In some lithium operations one or more of these are recovered as coproducts, but usually it has not been economically feasible to recover these materials.

From the brines of Searles Lake several coproducts are obtained in addition to the dilithium-sodium-phosphate. These include bromine, potash, borax, sodium sulfate (salt cake), and sodium carbonate. In the acid method of producing the compounds, salt cake is a by-product. In the alkali process calcium aluminum silicate is produced but is not now recovered.

Substitutes

Lithium, although high in price, is so desirable in most of its uses that few materials are substituted for it. In ceramics lead can be substituted for lithium in many instances, but it is less efficient and may be toxic.

In greases, lithium compounds impart water resistance and lubricating properties over extremes of temperatures. These properties apparently cannot be gained if other compounds, such as calcium, barium, or strontium compounds were used as the base component. Certain military grease performance specifications have been met only by lithium base greases.

Although lithium hydride is one of the most efficient hydrogen carriers known, for economic reasons it has been substituted by other efficient, but less expensive hydrogen carriers, such as calcium hydride.

Reserves

Reserves in the Kings Mountain area, N.C., were estimated by the U.S. Geological Survey in 1953 to be about 4 million units of lithia (a unit being 1 per cent of a short ton, or 20 lb.) in indicated ore averaging 1.7 per cent Li_2O, and about 124 million units in inferred ore averaging 1.3 per cent Li_2O. Reserves in the Black Hills, S.Dak., area are 1.2 million units in indicated ore averaging 1.2 per cent lithia, and 400,000 units in inferred ore averaging 1.2 per cent lithia. The upper deposits at Searles Lake, Calif., are estimated to contain 9 million units of lithia in solution averaging 0.015 per cent lithia and the pegmatite districts of New England, Colorado, Arizona, New Mexico, California, and Wyoming contain about 200,000 units in indicated ore averaging 1.2 per cent Li_2O[13].

The magnitude of reserves in other countries is less well known but very large in aggregate. Recent intensive exploration in several areas in Canada has revealed scores of pegmatite deposits containing a total of many million tons of lithium ore.

There are other potentially commercial sources of lithium. Large deposits of hectorite, a clay composed of montmorillonite group minerals which contain about 1 per cent lithia, are found near Hector, Calif.[13]. Tailing from the borax operations at Kramer, Calif., which contains about 0.4 per cent Li_2O, is another possibility. No commercial method has yet been found to recover the lithium from the tailing, but a process may be developed. Brines in numberous areas may also become commercial sources of lithium.

Sources of Statistics

The Bureau of Mines canvasses domestic lithium mineral producers annually and publishes a chapter on lithium in the *Minerals Yearbook*. Included in the chapter are data on world lithium mineral production and, when available, on exports from major producing countries. These data are compiled from foreign service dispatches and mineral production reports of foreign governments.

Production, Consumption, and Foreign Trade

In 1954 (the latest year for which figures are available) the domestic output of lithium minerals (including dilithium-sodium-phosphate) was 37,830 tons (see Table II). It has been estimated that production since that time has increased. No canvass is made of the consumption of lithium compounds, but estimates of 1956 consumption have been made; all are given in thousand pounds lithium carbonate equivalent in Table III.

TABLE II—Shipments of Lithium Ore and Compounds from Mines in the United States

Year	Li Minerals (short tons)	Value (thousands)	Li_2O Content (short tons)
1945-49 (average)	3,334	$259	312
1950	9,306	580	747
1951	12,897	896	956
1952	15,611	1,052	1,088
1953	27,240	2,134	1,767
1954	37,830	3,126	2,459
1955-57	See Note 1.	See Note 1.	See Note 1.
1958	See Note 2.	See Note 2.	See Note 2.

Note 1: Data not available.
Note 2: Figure withheld to avoid disclosing individual company confidential data.

TABLE III—Estimate of Lithium Consumption in 1956 (Thousand Pounds Lithium Carbonate Equivalent)

End Use	Canadian Mining Journal	Chemical and Engineering News	Business Week	Mining Engineering
Lithium greases	3,000	3,000	3,500	3,500
Ceramics and glass	2,300	3,000	3,500	5,000
Welding and brazing	1,200	250 to 500	800	1,520
Air conditioning	1,500	400	800	1,100
Alkaline batteries	650	250	600	600
Military and AEC	1,730		36,500	20,000
Miscellaneous	300			
Pharmaceuticals			500	250
Metallurgical				30

The American Lithium Institute sponsored a survey of grease manufacturers in 1958. It revealed that 72 per cent of the grease manufacturers responding produced lithium-base greases. The same survey estimated that by 1965 almost 42 per cent of the domestic automotive grease output will be lithium greases, representing about 250 million lb. a year, which is almost double the 1955 output of 133 million lb.* Imports of lithium minerals are not classified in foreign trade figures.

Self-Sufficiency

The United States, the largest producer and consumer of lithium compounds, has an adequate lithium reserve to sustain the industry indefinitely. Although no figures are available, it appears from general knowledge of the industry that plant capacities are large enough to meet anticipated consumption demands.

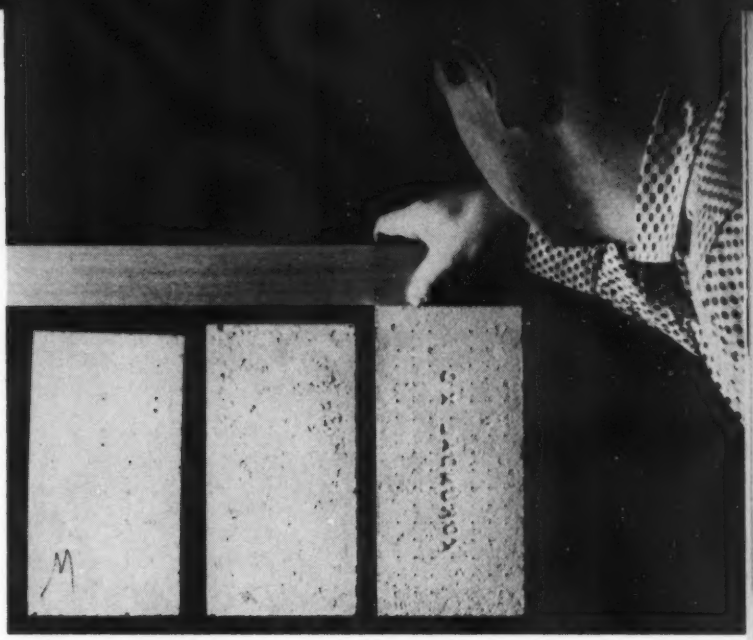
Lithium Corp. of America now processes imported Canadian ores at its chemical plant; however, should the Canadian supply be cut off, this firm's holdings in the Black Hills and Kings Mountain areas contain sufficient reserves to sustain production.

Known domestic sources of lepidolite are not large enough to furnish American Lithium Chemicals' raw

(*Continued on page* 598)

*Chemical Week, Grease Speeds Lithium's Production Growth, 82, No. 15, Apr. 12, 1958, pp. 37-38, 40.

Developing a refractory product which looks good in the laboratory, then proving its worth by service application, involves alternate approaches which seriously hinder research. To remedy this situation, it is necessary to employ the best possible system of information feed-back from the glass plant to the refractories manufacturer.



Three high-alumina bricks held 100 hours at 3000°F under a load of 25 psi. Mullite-bonded corundum brick (right) shows no subsidence.

New Trends In Refractory Research *

by Raymond E. Birch and Frank H. Walther, director of research and mineralogist, respectively, Harbison-Walker Refractories Co., Pittsburgh, Pa.

In the past 10 to 15 years, a number of new refractory materials and many modifications of existing products have been introduced for use in the glass furnace. The brick types include a wide range of compositions: *(1)* modified and improved silica and fireclay brick, *(2)* modified high-alumina brick varying from 50 per cent alumina to brick of 99+ per cent purity, *(3)* magnesia and magnesia-chrome variations, both burned and unburned, *(4)* forsterite and forsterite-magnesia combinations, and *(5)* zircon. In addition, numerous refractory specialty products such as castables, ramming mixes, and gunning mixes have been introduced and have taken a foothold in the glass industry. These compositions cover a range equal in magnitude to the brick types, and it is common today to introduce a new brick type with mortars and monoliths of similar composition.

Consequently, the engineer has a wide selection of refractories of various chemical compositions and physical properties. In any individual case the problem of refractory selection becomes one of narrowing the choice and choosing the refractory with the most promising chemical composition and physical properties. It is in this area that much information needs to be developed concerning the fundamental service conditions and their influence on refractory types. If it is assumed that the best refractory is also the most economical, only three types of information are needed: *(1)* all significant chemical and physical properties of the refractory, *(2)* complete knowledge of the furnace environment, and *(3)* the behavior of the refractory in such an environment.

Unfortunately, knowledge of the furnace environment is likely to be sketchy, involving unknown variables, and the reaction of the refractories to the environment is most often attained only by the trial-and-error method of service. Furthermore, it is, in many cases, impossible to translate a successful trial from one furnace to another. As furnace campaigns have lengthened it becomes a seemingly interminable matter to wait for the results of these service trials. Because of this situation the full potential of existing refractories is not entirely known. Refractories introduced into 1961 rebuilds cannot, in many cases, be fully assessed until sometime around 1965. What is needed is a practical, realistic program to minimize expensive periods of interpretation and translation.

Development Methods

Refractories now in wide use have been evolved through two general avenues of approach.

1. Improvements most commonly in the basic refractory technology, including advanced manufacturing techniques and quality control, and a better selection of raw materials. Rarely are compositions wholly new.
2. Chemical and mineralogical investigations concerning the systems encountered. We should include here the application of phase equilibrium data concerning the

*This paper was presented at the Glass Conference, Ohio State University, 1960.

Reader Service Card: Circle No. 21 →

From the nation's leading suppli

Solvay Chemicals for Glassmaking

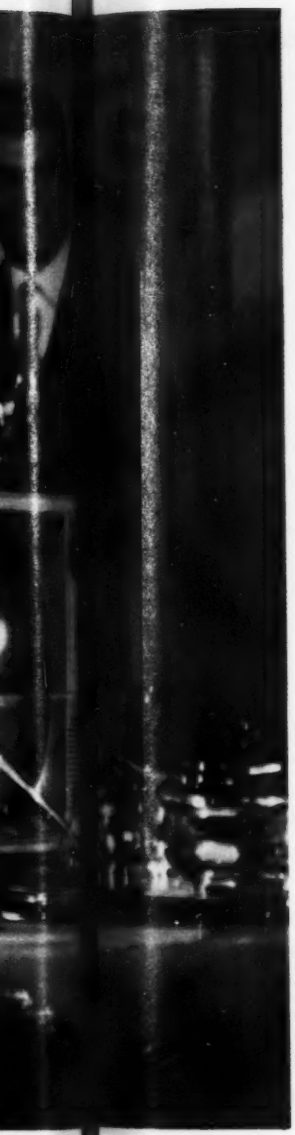
Ammonium Bicarbonate

Potassium Carbonate

Soda Ash

Mutual® Bichromates

pli f glassmaking chemicals



SOLVAY POTASSIUM CARBONATE

for clarity...for luster...for "ring" in quality glassware

Solvay® Potassium Carbonate is made for glassmaking . . . non-caking . . . free pouring . . . dust-free. And, as the nation's leading producer of chemicals for glassmaking, Solvay assures you of dependable supply and prompt delivery.

Solvay provides technical service, too, with an outstanding glass research laboratory and experience gained in over 75 years of working with the industry. Why not let Solvay work with you?

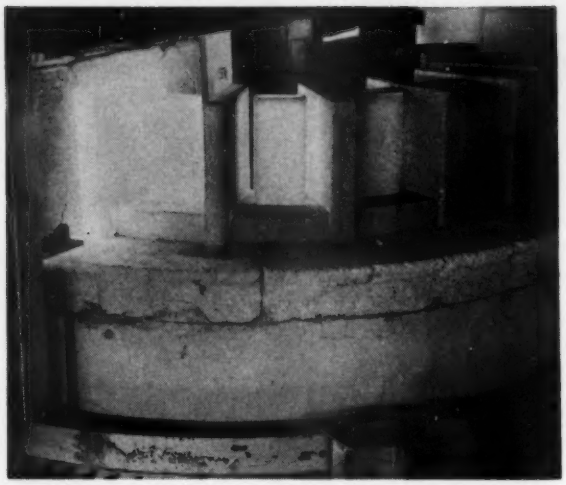
Allied Chemical

BASIC TO AMERICA'S PROGRESS

SOLVAY PROCESS DIVISION

61 Broadway, New York 6, N. Y.

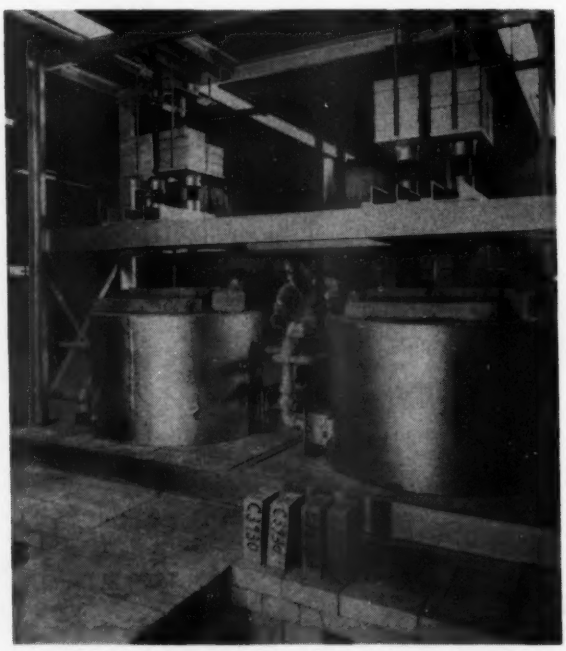
Branch Sales Offices: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • Houston
New Orleans • New York • Philadelphia • Pittsburgh • St. Louis • San Francisco • Syracuse



Rotary hearth furnace allows repeated heating and cooling of brick specimens. For normal testing cycle, temperature is 2370°F.

refractory oxides. This approach has also been used extensively in the examination of used refractories after service to deduce the chemical and physical environment which existed, and the influence of this environment on the stability of the refractories.

At Harbison-Walker's Garber Research Center, laboratory projects in all fields of refractory service are begun, and concluded, at the rate of about three a day. In the last 3 years some 125 projects for at least 50 glass companies have been completed. These postmortems on used refractories have been primarily mineralogical studies, and this approach to new and used refractories has been supplemented by various types of reaction studies and other physiochemical tests designed to substantiate and evaluate the studies.



These load-testing furnaces, with supplemental oxygen, allow testing on full-sized brick at 3400°F (1870°C).

Before discussing in more detail some of the inadequacies of present-day testing, we should point out areas where current techniques have led to noteworthy improvements in refractories. At the same time, we should indicate the significant trends which will influence refractories in the immediate future.

In many areas, such as the glass tank crown and superstructure, the practical problems involved can be rather clearly related to refractoriness, resistance to corrosion by volatile alkalies and alkaline dusts, hot load bearing capacity, and thermal expansion and conductivity. These problems, in general, are well understood, and good testing facilities have been designed to measure their characteristics in refractory specimens. Gas-fired load-testing facilities have now been standardized and permit testing of full-sized brick to approximately 2100°F. When modified by oxygen injection, 3400°F can be attained as a routine procedure. There has also been great improvement and simplification in other test procedures.

REGENERATOR MAINTENANCE

In many industries, depending on furnace operations, the daily maintenance of the refractory structure receives as much consideration as the problems of original construction. For example, the open hearth steel furnace uses a greater tonnage of refractories gunned and shovelled through its doors than is used in its construction. While the introduction of granular refractories into a glass tank could not even be considered, the practicality of gunning regenerator walls is something which has been effectively demonstrated.

In one such repair, localized worn areas in the port uptake and regenerator walls were repaired in this manner during a checker replacement. To restore the original contours of the walls and crown 2 to 6 in. of material was applied to the worn areas, saving a considerable amount of time and money. This particular installation has been in service for over 2 years and still seems to be in excellent condition.

As everyone knows, the general trend throughout many industrial processes has been toward increased operating temperatures in order to improve production and efficiency. This has resulted in a demand for materials of higher refractoriness and correspondingly enhanced hot load bearing capacity. At temperatures of the order of 3000°F, refractories, almost without exception, show distress resulting from their own liquid formation due to minor impurities associated with the raw materials. We are just now approaching a period where we will be working with a whole series of refractories having almost no liquid phase at furnace operating temperatures.

For 20 years, super-duty silica brick has been such a refractory, and it has been a mainstay of the furnace

	Super-Duty Silica	Mullite-Bonded Corundum	98-grade Periclase
Refractory Base	99.1 per cent (SiO_2 + CaO)	99.8 per cent (Al_2O_3 + SiO_2)	98.1 per cent MgO
Impurities			
Silica	——	——	0.71
Alumina	0.20	——	0.20
Titania	0.02	Trace	Trace
Iron Oxide	0.70	0.10	0.21
Alkaline Earths	Trace	Trace	0.63
Alkalies	0.04	0.10	0.10
	0.96 per cent	0.20 per cent	1.85 per cent

TABLE I—Pure Load-Bearing Refractories

builder. Now there are to be two more refractories of exceptional purity: 98-grade periclase and mullite-bonded corundum. Both basic oxides composing the refractory base and accessory impurities are shown in Table I. The purity of these products is reflected in their excellent load-bearing capacities. Table II shows the percentage linear subsidence of these products as compared to other refractory types when held for 24 hours at each 100°F interval.

The mullite-bonded corundum composition has particularly outstanding load-bearing qualities. This product shows no subsidence after 100 hours at 3000°F under 25 psi. In comparison, other corundum-mullite compositions give a considerably higher subsidence. In addition to excellent load-bearing capacity, the mullite-bonded corundum and high-purity magnesia have excellent spalling resistance and volume stability at high temperatures. The benefits of high purity are just now beginning to be fully realized, and it is through this avenue that the engineer will be able to attain the higher operating temperatures which will permit not only greater production rates and efficiency, but also the practical capability of producing higher melting type glasses.

Future Refractories

New refractories for the glass industry are presently under development in the laboratory. However, before the full benefit of these products can be realized, much information concerning their fundamental reactions with the physical and chemical environment in which they are to be placed must be systematically investigated. Our own laboratory approach to the problem has been to isolate individual service factors wherever possible, and to study them singly before viewing their combined effects. It will require close cooperation between the consumer and the refractory producer to define such conditions as the reaction to the various types of batch carry-over throughout the temperature ranges encountered under service conditions.

A great amount of data concerning the reactions between the primary batch constituents and refractory oxides is presently available. It has been obtained through the observation of relatively simple reaction tests in which either raw materials or fabricated refractory products are exposed to various chemical constituents.

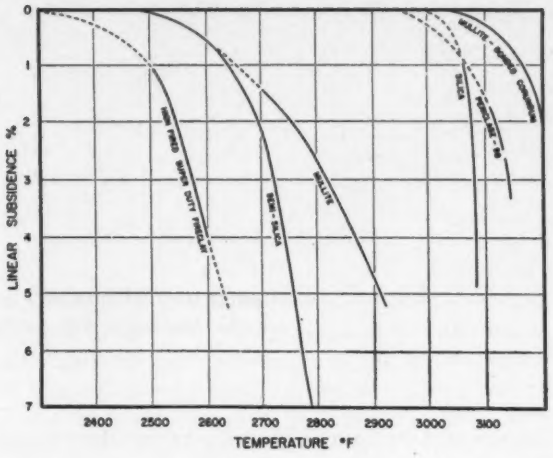
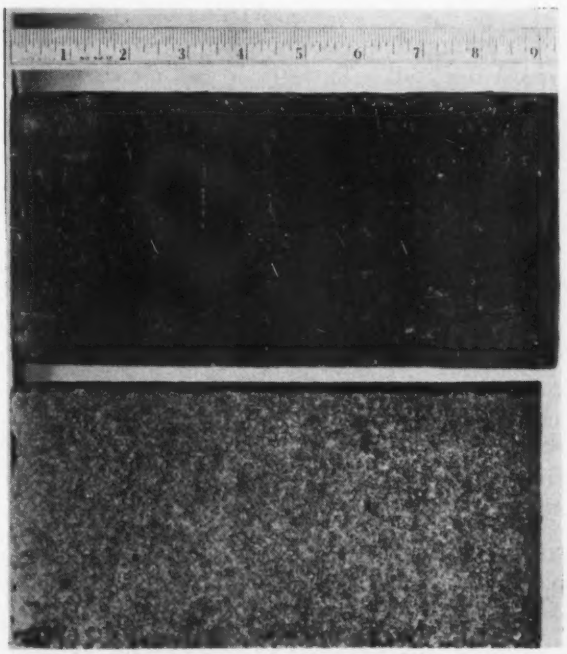


TABLE II—Linear Subsidence Comparison. (Curves based on loading of 25 psi held for 24 hours at each 100°F level.)

The importance of studying these basic reactions should not be minimized; however, one must at the same time recognize that these laboratory tests, at best, only approximate actual service conditions. The physical form of the reactants greatly influences the ultimate reaction sequence, as well at its rate and the type of refractories destruction.

Therefore, in order to obtain a critical measure of a product's ultimate performance, laboratory tests must be designed to simulate the particular conditions for which the refractory is intended. This is our present aim. Due to the complexity of the necessary testing equipment and the extended time required to complete an

(*Continued on page* 599)



Two basic refractory bricks after undergoing 75 half-hour cycles of heating and cooling in rotary hearth furnace.

American Scientific

A TECHNICAL

Conclusion of two-part review covering papers delivered at the Society's 6th Symposium in New York City

Release of Alkalies and Fluorine From Glasses and Their Influence on Glass Sealing

By Dr. Josef Francel, Senior Research Engineer, Kimble Glass Co., Toledo, O.

The release of gases by heat plays an increasingly important role in electron and TV tubes; extensive studies have been made to understand the factors influencing this phenomenon. Only limited attention has been given in the past to the heat effects on glass which affect the glass sealing characteristics. When a flame makes contact with glass, the flame becomes colored, *e.g.*, yellow from sodium in a glass, purple from potash, or red from lime. This flame coloring is believed to be due to volatilization of glass components resulting in alterations of glass composition at the flame contact spot. When alkalies are released, the net result is increased silicon content in silicate glasses. When fluorine is released, two things can happen to the glass: (*1*) the silicon content will be higher, or (*2*) fluorine can take some silicon with it in the form of a compound with very high vapor pressure known as silicon tetra fluoride (SiF_4) or silicon hexafluoride (SiF_6). In the latter case, the silicon content can be lower or equal to the original glass composition before heat was applied. Alkali and fluorine release have been examined to find out which of these conditions is actually prevailing. This problem is, of course, of considerable practical importance because it may offer a possibility of designing glasses which might remain unchanged by direct flame, and the glasses could be then sealed without any composition stresses. This could be achieved if the process of alkali and fluorine release could be controlled and balanced so that the siliceous excess remaining in glass after the alkalies left it could be removed by volatilizing fluorine out as silicon fluorides. For a glassblower, this balance could mean mechanically strong seals and chemically homogeneous sealing edges.

Glass in Space

By Arthur F. Shoemaker, Corning Glass Works, Corning, N. Y.

The following environmental conditions and requirements were presented in order to select glasses for high-performance manned flight.

(*1*) *Good optics for viewing angles up to 60° off-normal.* The window or viewing unit will have to be made of more than one panel—probably four or five. Angular vision through four or five panels is not likely to be good. The loss in transmission caused by long glass paths—and the reflections from all those surfaces—will reduce visibility to practically nothing. A significant gain can be made, however, by an application of a coating of Mgf on many of the surfaces. This coating, when applied in properly graded thickness, can reduce reflections to a point where they are not detected. Normally, if a window package of this type ends up with a total transmission in the order of 40 per cent, satisfactory viewing can be achieved.

(*2*) *Launch shock.* This condition can be accommodated through a rigid mounting frame and good gasketing on the edges of the glass. Of course, results will depend on the position of the glass in relation to the direction of shock. Normally, the glass would be in an "edge-on" direction, which would result in only a compression moment, plus edge impact. However, if by some weird requirement the glass were normal to the shock, it would mean a tremendous increase in panel thickness as well as mounting frame "beef-up."

(*3*) *Vibration.* Cushioning or damping between glass and frame and/or frame and vehicle body will be required. Also, a test would be necessary to determine whether the particular type of glass and its shape and thickness would set up harmonic vibration.

(*4*) *Exposure to extreme vacuum under various levels of changing temperature.* Except for the pressure differential which would be induced, it is not expected that vacuum would be detrimental. The effect of temperature variation would be reflected only in different expansion or contraction characteristics between the glass and the metal framing member.

(*5*) *Positive seal of glass to vehicle.* This is probably the most important condition that would have to be met, especially if the mission is to be in space for a significant length of time. The problem is that the vehicle will have to carry its own regenerating oxygen supply. Any leaks will reflect in loss to this supply, and

because of weight and storage limitations, there would not be much leeway allowed for excess supply. Therefore, it will be necessary to make a glass-to-metal seal capable of withstanding shock and vibration loads, as well as temperature and pressure differentials, and of being patched in flight if a leak does develop. In view of this, the nonporosity of glass suggests a glass inner capsule liner. If this were ever considered—and it is not so inconceivable as it might seem—lampworkers would certainly be faced with a tremendous challenge.

(6) *Micrometeorite impact.* There is no data concerning what the effect on glass might be. The particles are extremely small, 0.005 in. to 0.0005 in. in diameter. Depending upon time and space, it could be expected that several thousand impacts might occur. What data there is has been extrapolated from the Discoverer and Explorer satellites which carried equipment that recorded number and energy of impacts. The best guess to date is that only a pitting would result. The probability of impact by particles significantly larger than indicated is based on statistical means. If such impact does occur, obviously a catastrophic failure would result.

(7) *Radiation shielding.* This presents no problem except that related to the total time of exposure and to the type of radiation. Normally, fused silica glass will handle the condition without discoloration.

(8) *Ultraviolet radiation.* This is the portion of the spectrum which causes burning of the skin as well as damage to the eyes. In order to perform an absorption function, a filter glass would have to be selected that would have sharp cut-off characteristics at around 3800Å. Probably a new glass would have to be used—one that would meet more closely the given mechanical and thermal conditions in addition to having the ultraviolet cut-off.

(9) Re-entry temperatures up to 2200°F. The deciding factor here is the amount of time at this temperature under the concomitant factor of pressure. Fused silica could meet this requirement if the other criteria were right. It may be necessary, however, to have a sliding metal shield that would cover the window area during this portion of the flight.

(10) Protection of occupants from infrared radiation at 2200°F re-entry temperatures. This again involves functions of temperature and time. For relatively short times—say 5 to 10 minutes—the use of multipanels with an infrared reflectant coating on the surfaces should do fairly well. Air gaps between panels will inhibit transfer by conduction and convection. The IR coatings will reflect a high percentage of the energy at these wave lengths. For longer periods of time, the sliding metal shield appears to be the best solution.

High-Temperature Glasses

By Thomas H. Elmer and Martin E. Nordberg, Research and Development Div., Corning Glass Works, Corning, N. Y.

The following special features and applications of various Vycor "reconstructed glasses" were presented.

Code 7900: No restrictions on ultraviolet transmittance. It is used chiefly in chemical ware and tubing for general laboratory use, but is also available in sheet and other blown or pressed ware.

Code 7905: Controlled for high infrared transmission below about 3-micron wavelength. An 0.125-in. thickness of Code 7905 glass will transmit a minimum of 80 per cent at 2.72 microns. Code 7905 glass domes are used in heat sensing missiles which "see" or "home-on" infrared waves.

Code 7910: An ultraviolet transmitting glass specially prepared to transmit at least 70 per cent at 254 millimicrons for 2-mm thickness. Its annealing point is 950°C. The glass has wide applications as envelopes for low-pressure mercury vapor lamps.

Code 7911: An ultraviolet transmitting glass with low gas content. It has high electrical resistance and low power loss. The glass was designed for medium-pressure mercury vapor lamps.

Code 7912: Has the same overall properties as Code 7910, but is more transparent to wavelengths below 254 millimicrons. It is available only in tube form and is chiefly used in low-pressure mercury arc, germicidal, and ozone-producing lamps.

Code 7913: Has a low gas content. It has no special restrictions on transmission. Because of its excellent heat resistance it is used in containers for sintering, calcining, high-temperature fusion, and chemical reaction at elevated temperatures. In tube form, it is used as thermocouple-protecting tubes and tips, heat sheath tubing, hot-furnace sampling tubes, etc. This glass is also available in optical grade.

Code 7914: Originally made in tubing form for jackets in mercury vapor lamps. It has at least 20 per cent transmittance at 254 millimicrons, high electrical resistivity, and low power loss.

Code 7915: Intended for severe service of many thousands of hours duration in high-pressure mercury vapor lamp applications. It will not darken or solarize. It is nearly 98 per cent silica, and is controlled to contain less than 0.002 per cent Na_2O and 0.003 per cent water (determined by infrared adsorption data) to minimize devitrification and out-gassing in service. The annealing point is about 1060°C, and Code 7915 glass is least likely to deform at high temperatures.

Code 7916: Has the highest resistance to deformation at high temperatures. It is presently being made in small-diameter tubing, known as "core tubing," for manufacture of perforated turbine buckets for jet engines by the investment casting process.

Code 7930: Usually referred to as "porous" or "thirsty" glass. Code 7930 is the intermediate form of porous glass obtained in leaching the base glass used in manufacture of the final fired Vycor brand glasses. It has an average pore diameter of 40 Å. Its chief commercial application is as a moisture-getter in electronic components.

Code 7950: A red-stained reconstructed glass which absorbs most of the visible light from a tungsten filament (2700°K) but effectively transmits infrared. In tubing form it is finding increasingly wide application as an envelope for radiant heaters.

Code 1950: Similar to Code 7915 glass with even more stringent specifications. Like Code 7915, it was also designed for high-pressure mercury vapor lamps.

Mechanical Requirements for Solder Glass Seals on Glass

By R. R. Kegg, Kimble Glass Co., Toledo, O.

Two general methods of application were considered. The first is called "cold application" and is accomplished by taking a finely ground powder and mixing it with a vehicle consisting of 1.5 per cent nitrocellulose in amyl acetate. This vehicle readily decomposes below the softening point of the solder glass so that it does not cause contaminated or seedy seals. The sealing edge must be thoroughly cleaned with alcohol or acetone just prior to solder glass application. Contamination can cause failure from the standpoint of thermal shock and electrical breakdown.

The article can be dipped in a rather thin paste, or it can be applied by using a thick paste which is introduced into a tooth paste or nasal ointment tube and the desired amount extruded onto the sealing edge. Another piece of equipment that can be used is the Model No. C600 Almite gun, which has an orifice made by attaching a piece of ⅛-in. ID copper tubing. In all cases, excellent green strength is obtained through the use of the nitrocellulose amyl acetate vehicle. In some seals, such as butted pieces of tubing and TV bulbs, the excess solder glass can be removed with a knife or spatula, after drying, without disrupting the sealing edge.

The second method of applying vitreous solder glass is called the "hot dip" method. Here the solder glass is heated, in a platinum container, far above its softening point to a point where the solder glass has viscosity close to that of water. The component glass parts or metal parts are usually preheated close to the annealing point of the glass before dipping. The part is dipped into the hot solder glass for 10 to 15 seconds, removed, and held in position for 5 seconds to set up the solder glass. It is then placed back into an oven to anneal. With this method there is a solution of the parent glass by the solder glass, and a better seal is obtained. After annealing, the parts can be sealed at a later date by processing at a temperature approximately 75°F above the fiber softening point of the solder glass. Satisfactory seals can be made by having just one of the component parts pretreated, but it has been found that better seals can be obtained by coating both edges prior to sealing. Generally, seals made by the "hot dip" method show a higher seal strength than that of the "cold paste" application.

A Bakeable Diffusion Pump Assembly for Ultra high Vacuum

By G. L. Krieger and G. D. Cosgrove, Sandia Corp., Albuquerque, N. M.

A 2-stage pump, with a cut-off provided between the first and second stages, has been designed and tested. Using this, the high-vacuum jet (and associated structure) can be rendered inoperative and baked out, while the first stage continues to function and maintains the required high vacuum in the system.

The No. 1 heater bulb is made of 7052 glass with 0.040-in. Kovar leads which act as support for the bulb and supply power to the heater. The bulb is made in such a way that the lower lip extends down about 1/16 in. over the re-entrant edge of the No. 4 mercury flow tube. The cut-off water jacket extends from the top of the heater bulb down around the bulb to the mercury flow tube. The water lines for the water jacket are bent down and out to the inside wall of the pump at the point where the outer water jackets are divided.

The Kovar heater leads extend down through the mercury flow tube to a section of 7052 glass provided for the Kovar-to-glass seals. The flow tube is cut at the center of the 7052 section, and the heater bulb is inserted into the water jacket with asbestos spacers for alignment. The beaded leads extend beyond the cut end to allow a 90° bend to bring the heater leads through the wall of the mercury flow tube; the two parts of the flow tube, together with the beaded leads, are sealed in one operation. Flexible leads are spot welded to these leads, making it possible to pull them through holes provided for them in the outer wall of the pump.

The pump was operated over a period of several weeks, with the interstage cut-off in both closed and open condition for extended periods, during which it functioned satisfactorily at all times. Cold trap and upper jet assembly bake-outs were carried out on several occasions, after which the pressure achieved appeared to be limited by the extent to which the ionization gauge could be out-gassed, a value of 7 by 10^{-9} mm Hg being the lowest observed. The high-vacuum stage can be baked while the lower stage remains operative, providing the pumping speed is about 5 *l.* per second. The pumping speed with both stages functioning is 10 *l.* per second.

Glass and Metal Ultrahigh Vacuum Systems

By R. E. Honig, R.C.A. Laboratories

Two types of ultrahigh vacuum systems, capable of reaching 10^{-10} torr (mm Hg) have been designed, constructed, and evaluated with the help of small mass spectrometers.

Honig used dynamic, multiple trap systems to determine the partial pressures of residual gases, with a small mass spectrometer, down to the 10^{-11}-torr level, and to study surfaces cleaned by ion bombardment. The apparatus of this system consisted of the customary mechanical forepump, a ballast volume, a mercury diffusion pump, a dry ice trap to prevent the Hg vapor from diffusing back, two liquid nitrogen traps in series, and the miniature mass spectrometer used to determine the gases contained in the sample. Three separate ovens were employed to process the system. Oven No. 1 bakes out the first liquid nitrogen trap. Oven No. 2 covers the remainder of the high-vacuum system, and the small, removable sample oven heats the quartz tube containing the sample. In operation, the system is first evacuated and baked for several hours by ovens No. 1 and 2, at temperatures of about 350°C and 400°C, respectively. Next, oven No. 1 is removed and trap No. 1 cooled with liquid nitrogen. Subsequently, oven No. 2 is removed and liquid nitrogen placed on trap No. 2. By this procedure, pressures in the 10^{-10}-torr range are usually reached after a few days. Finally, the sample alone is heated by the sample oven to the temperature required to remove the occluded gases.

While demountable metal systems or components have been used for many years, they usually employed rubber gaskets and could therefore not be baked. A fully bakeable system using metal gaskets and conventional diffusion pumps has been described by Mark and Dreyer.

The oil-free, all-metal vacuum system used for the evaporation of superconducting films as described by Caswell is different; it uses a water aspirator and a liquid He finger instead of a forepump, while two ion-getter pumps and a second liquid He finger replace the conventional diffusion pump. In this fashion, Caswell has carried out evaporations at pressures below 2 by 10^{-9} torr, free of hydrocarbon contamination. The system to be discussed in some detail below follows the general approach chosen by Caswell, but employs a simplified design that combines very large pumping speeds with a low consumption of liquid helium.

While glass systems after proper processing will produce vacua in the 10^{-10}-torr region, the pumping speed realized is severely reduced by the cold traps required to protect the working space from the pump vapors. Contamination by hydrocarbon vapors from the mechanical forepump is unavoidable when the system is first pumped down, and can be reduced only by prolonged baking. Baking temperatures are, of course, limited to below the softening point of the glass employed, and it is therefore impossible to remove all occluded gases from the walls. Around-the-clock attention is required to keep up the refrigerant level in the cold traps, and the noisy mechanical forepump is subject to wear. Complex devices are required to protect the equipment, particularly should power and cooling water fail. A glass system cannot be made demountable and at the same time retain its ultrahigh vacuum character. Finally, glass components are fragile and apt to fail, often causing extensive damage to expensive filaments. The only true advantage of a glass system lies in its relatively easy fabrication by a skilled glassblower, allowing its shape to be changed quite readily.

Metal systems, on the other hand, are truly demountable. A sorption pump, free from any hydrocarbon contamination, produces the forevacuum required by the ion-getter pump, and is valved off immediately after the initial pump-down. The full pumping speed of the ion-getter pump is available since there are no in-line cold traps to separate it from the working space. The only cold trap used is the liquid helium trap, which is filled only when vacua below 10^{-10} torr and very high pumping speeds are required. Component parts are made of stainless steel prefired in dry hydrogen at 1065°C; thereby all occluded gases except H_2 are removed. To remove the residual H_2, it would be preferable to vacuum-fire all SS parts. This system contains no moving parts, requires no cooling water, and is not ruined by a power failure. Its major disadvantage lies in the fact that fabrication is complex and requires special facilities and advanced knowledge in arc-welding and brazing.

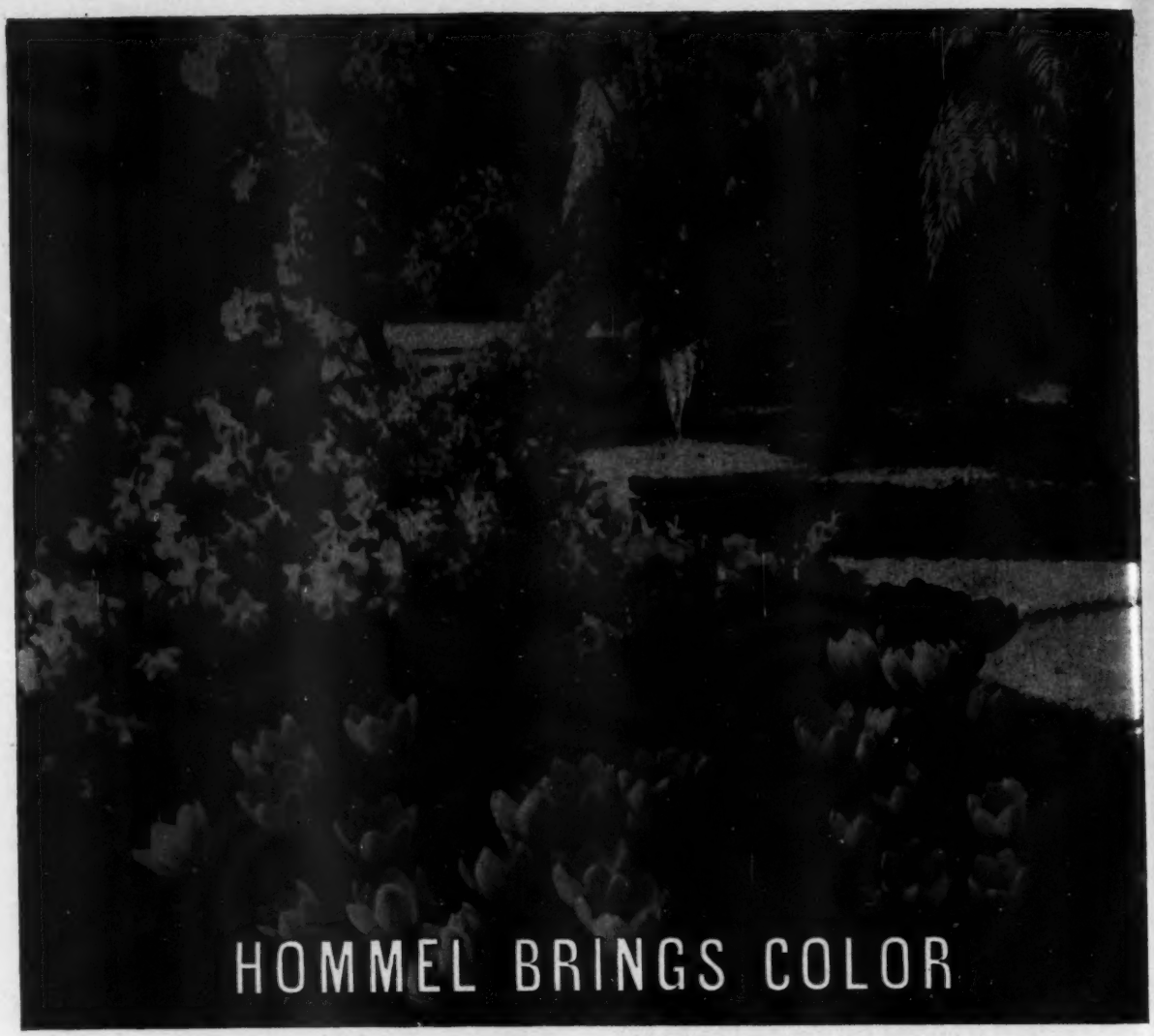
Vacuum Forming of Glass

By Oscar H. Grauer, Fischer & Porter Co., Warminster, Pa.

Vacuum forming of glass is relatively new in the field of glass technology. While glass blowing dates back at least 20 centuries, the first crude vacuum reforming of glass began only about 50 years ago. Vacuum-formed glass was originally developed largely because of the need for tapered glass tubing of accurate internal dimensions which could reproduce its calibrated ID dimensions from tube to tube.

The principle of vacuum forming glass is simple. A raw glass tube is bottomed off, or stoppered, at one end. It is evacuated by means of a pump, and the temperature of the glass is increased to the region between

(*Continued on page* 599)



...OUT OF THE HOT HOUSE

Nature produces beautiful flowers at a variety of temperatures. This same latitude can be yours when you choose Hommel glass colors . . . they're matched to your exact color desires. You'll find Hommel glass colors stronger . . . saving you money in broader coverage. And they have superior acid and alkali resistance.

Whether your production requires hot or conventional squeegee printing, spraying, or brush application, you'll find Hommel colors meet your specifications. And the Hommel research staff stands ready to assist you on specific problems.

HOMMEL

GLASS COLORS

THE O. HOMMEL CO. PITTSBURGH 30, PA.

West Coast Warehouse, Laboratory and Office, 4747 E. 49th Street, Los Angeles, California Dept. GI-1061

POTTERY • STEEL AND CAST IRON FRIT
CERAMIC COLORS • CHEMICALS • SUPPLIES

Our Technical Staff and Samples are available to you without obligation. Let us help with your problems.

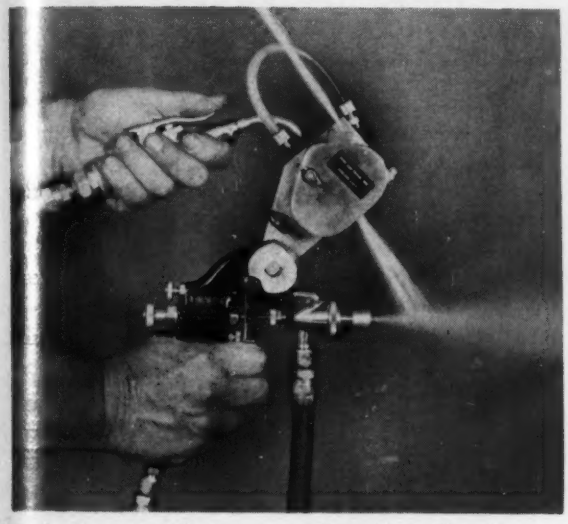
World's Most Complete Ceramic Supplier

SPRAYED REINFORCED PLASTICS

by Edward S. Mylis,

Plastics Div., Allied Chemical Corp., Toledo, O.

With the uses of fiber glass reinforced plastics increasing every day, this new manufacturing technique shows great promise.



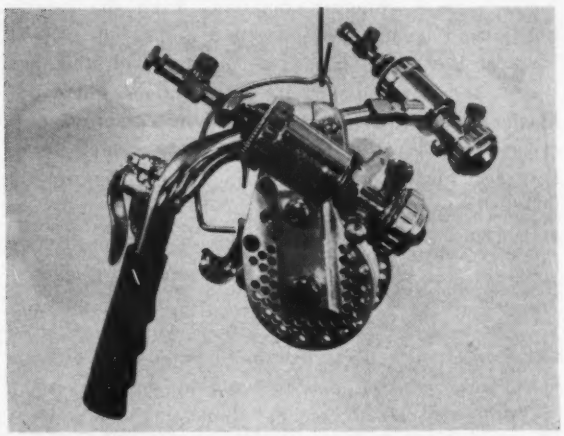
Single-, 2-, and 3-nozzle guns are currently used in the fiber glass spray-up process. Shown here is a Finn & Fram 2-nozzle gun.

The "spray-up" method of manufacturing reinforced plastics is based on the use of newly developed spray-up guns. Essentially these guns consist of a dual-nozzle resin spray system and a "chopper," or reinforcement distributor. In operation the resin coats, or wets-out, the reinforcement materials as both are sprayed or blown simultaneously onto the mold. Subsequent compacting of the materials, or rolling out, produces a dense, strong, useful laminate soon after the resin hardens. The introduction of this new processing technique has complemented conventional manufacturing methods in some areas and replaced older and more expensive fabricating methods in others. This system has also given to the local building contractor a new approach to on-the-job construction.

Applications and Advantages

Immediately apparent in this new system is the ease of fabricating a fiber glass reinforced laminate. The equivalent of (*1*) precutting glass mat or cloth, (*2*) measuring a quantity of resin, (*3*) mixing in the catalyst, and (*4*) finally spreading the catalyzed resin over the glass can be accomplished by pulling the trigger of a spray-up gun. If desired, these operations can be performed separately as well as simultaneously. Both hand lay-up and spray-up laminating require a brushing or rolling of the wet laminate to compact, remove air bubbles, and fill any void sections. However, as the complexity or difficulty in cutting, fitting, or preforming fiber glass for the particular part increases, the more advantageous the spray-up laminate becomes, since its formation replaces the need for a separate pattern or preform. It has been reported that difficult lay-up parts can be made at a labor savings of up to 40 per cent by use of the spray technique.

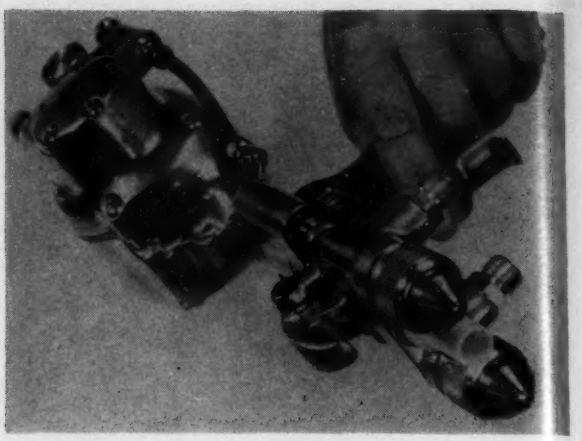
Raw material savings have also been achieved by reducing the amount of resin waste inherent in the batch-



This 2-nozzle gun has been put on the market by the Rand Development Corp., recently consolidated with Sealzit Co. of America.

mixing operation. Also, little reinforcement is wasted in overspray, as compared to the scrap pieces left over when a pattern is cut from rolls of mat or cloth. The mobility and relative simplicity of operation allows the spray-up gun to be used in many areas and applications where previously only specialists could operate. This opportunity is attracting increasing numbers of local contractors into broader fields of endeavor. Typical of

Shown here is a 3-nozzle gun manufactured by Peterson Products of Belmont, Calif. All guns can be used with either single- or 2-pot system.



Another of the 3-nozzle guns is currently available from the Sealzit Co. of America, producers of fiber glass and plastic spray equipment.

this new work has been the coating or lining of cement swimming pools and metal storage tanks and the actual fabrication of reinforced plastic at the site. The repair of oil storage tanks by the spray-up method has been pioneered by one of the major oil companies.

The spray-up technique has also been used for the coating of walls, boxcars, storage bins and industrial ducts to increase service life and improve cleaning and sanitary conditions with decreased maintenance. The local contractor is constantly finding new and different applications for reinforced plastics by bringing the plastic to the job. In addition, industry is making wide-spread use of the spray-up system to manufacture both new and old products. Several major fiber glass boat manufacturers have switched completely from the conventional hand lay-up techniques to the spray-up method. Most of the others have experimented with this new system and have adopted it for operations where economic advantage or greater processing ease have been experienced. Truck and sport car body manufacturers have also found the spray system advantageous for the relatively short production runs of complex parts experienced in these lines.

Raw Materials and Operation

Theoretically, many plastics or plastic-like materials and reinforcing agents can be used in the spray-up guns. However, the great majority of systems now in operation use polyester as the resin and fiber glass as the reinforcement material. This combination will be used here to illustrate the functioning of the spray-up gun system.

The resin spray systems are of two major types. In one system polyester resin is placed in *two equal-sized tanks*. To one tank is added a catalyst or hardening agent—a peroxide. A promoter, or special chemical that further accelerates catalytic action, is added to the second tank. In operation, each tank feeds approximately half of the resin being sprayed. Each half, the catalyzed and the promoted portions, are sprayed together, usually from separate spray heads. The resin, then combined with the complete hardening system, gels and cures at room temperature. As in all polyesters, the gel time or working life is controlled by the amounts of catalyst and promoters used. Because the catalyst decreases the stability of the resin, the catalyst pot is usually cleaned every 4 to 48 hours, depending upon the temperature.

The other major resin system, called a "catalyst gun," overcomes the above stability problem. This system places the promoted polyester resin in *one large tank* and only the catalyst in the other smaller tank. As catalyst and resin do not come in contact before leaving the system, no tank is subject to gelling. However, as catalyst is used only to the extent of 0.5 to 2 per cent based on weight of the resin, the metering of this small amount of critical component is often difficult to control with any degree of accuracy. Therefore, the choice between these two systems is a matter of individual requirements.

(*Continued on page* 584)

A 2-nozzle gun is used to spray a recently fiber glassed surface where a high resin content is required.

PRODUCERS OF SPRAY-UP EQUIPMENT

Manufacturer	Recommended Resins	Reinforcement	Type Sale	Comments
Aust & Shuttler & Co. M.A.S. Kunststoffmaschien G.M.B.H. Dusseldorf, West Germany	Polyester (2-tank system)	Glass Breaker Aggregate Blower	Outright	——
I. G. Brenner Co. Special Machinery 32 East North St. Newark, O.		Glass Breaker	Outright	Manufactures glass-breaking equipment only.
Fiberlay, Inc. 1158 Fairview, N. Seattle 9, Wash.	Polyester (2-tank system)	Continuous Glass Feeder	Outright	
Finn & Fram, Inc. 9765 Shadow Island Dr. Sunland, Calif.	——	Glass Breaker	Outright	Manufactures a catalyst injector to be used with standard spray system.
A. Gusmar, Inc. Woodbridge, N. J.	Epoxy	Glass Breaker	Outright	——
Hupp Engineering Associates P. O. Box 3290 Sarasota, Fla.	Polyester (2-tank system)	Glass Breaker Aggregate Blower	Royalty-free License	Training school offered.
Peterson Products Industrial Reinforced Plastics P. O. Box 871 1325 Old Country Road Belmont, Calif.	Polyester (2-tank system)	Glass Breaker Aggregate Blower	Outright	Training school offered.
Rand Development Corp.* 13600 Deise Avenue Cleveland 10, O.	Polyester (catalyst gun)	Glass Breaker	License and Royalty	Training school offered.
Sealzit Co. of America* 3640 Chicago Avenue Riverside, Calif.	Polyester (2-tank system)	Glass Breaker Aggregate Blower	Outright	——
Spray-Bilt, Inc. 3605 East 10th Court Hialeah, Fla.	Polyester (2-tank system)	Glass Breaker	Outright	Training school offered.

*These two companies have consolidated.

Workmen at the Bertram Yacht Co., Miami, Fla., engage in the fiber glassing of a 31-ft. inboard power boat hull.

Workman at right uses gun to spray resin on the boat hull, while the man at left follows behind with roller to pack resin in place.

Reinforcement Handling

As in most reinforced plastics, fiber glass is the predominating reinforcement in use today for spray laminating. Fiber glass roving is drawn from a creel by the chopper which breaks the roving into the desired fiber length. This length can be varied from ½ in. to 4 in., although 1½ in. to 2 in. is the most common. Some systems do not break the glass into short lengths, but feed the roving in a continuous stream. Because of the high degree of static electricity developed with silane-finished glass as it passes through the chopper, hard chrome finishes are used almost exclusively. However, silane-finished glass is currently being developed to overcome this handicap.

By means of attachments, or relatively simple adaptations, many of the gun systems can be used to spray or blow various materials other than fiber glass. These materials or aggregates can usually be anything in granular form, such as sand, chopped cork, or marble chips, which can add desired and significant properties to the laminate or coating. Decorative effect, skid resistance, improved physical properties or, in many cases, over-all cost reduction can be accomplished.

Physical Properties

The physical properties of the generally sprayed polyester fiber glass laminates are comparable to conventional hand lay-up mat laminates (see Table I). As is the case with all fiber glass reinforced laminates, the glass content primarily determines the strength of the part. In spray-up laminating, the resin-to-glass ratio is usually determined by the working or wet-out facility of the two components. This ratio is kept between 25 to 32 parts glass to 68 to 75 parts resin for the most practical operating conditions. Of course, the total strength of any laminate depends upon the thickness of the part, and the guns do facilitate reinforcement at areas of particular stress by simply allowing additional material to be sprayed on the area to be strengthened.

While one man sprays walls of swimming pool, the second and third follow behind with roller and squeegee to pack fiber glass.

TABLE I—Typical Physical Properties of Spray-Up Laminates*
(Cure at Room Temperature)

Test	Value
Flexural Strength (psi)	20,000 to 26,000
Modulus of Elasticity in Flexure (psi)	750,000 to 950,000
Compressive Strength (psi)	18,000 to 22,000
Tensile Strength (psi)	10,000 to 15,000
Elongation (per cent)	1.3 to 1.7
Impact Strength (ft.-lb. per in. of notch)	8 to 12
Water Absorption (per cent, 24 hours)	0.1 to 0.3
Resin, Polyester (per cent)	65 to 75
Glass (per cent)	25 to 35

*Physical properties were obtained from laminates prepared in the laboratory with "Plaskon" polyester PE-247 and from other laminates obtained from actual industrial applications.

Disadvantages

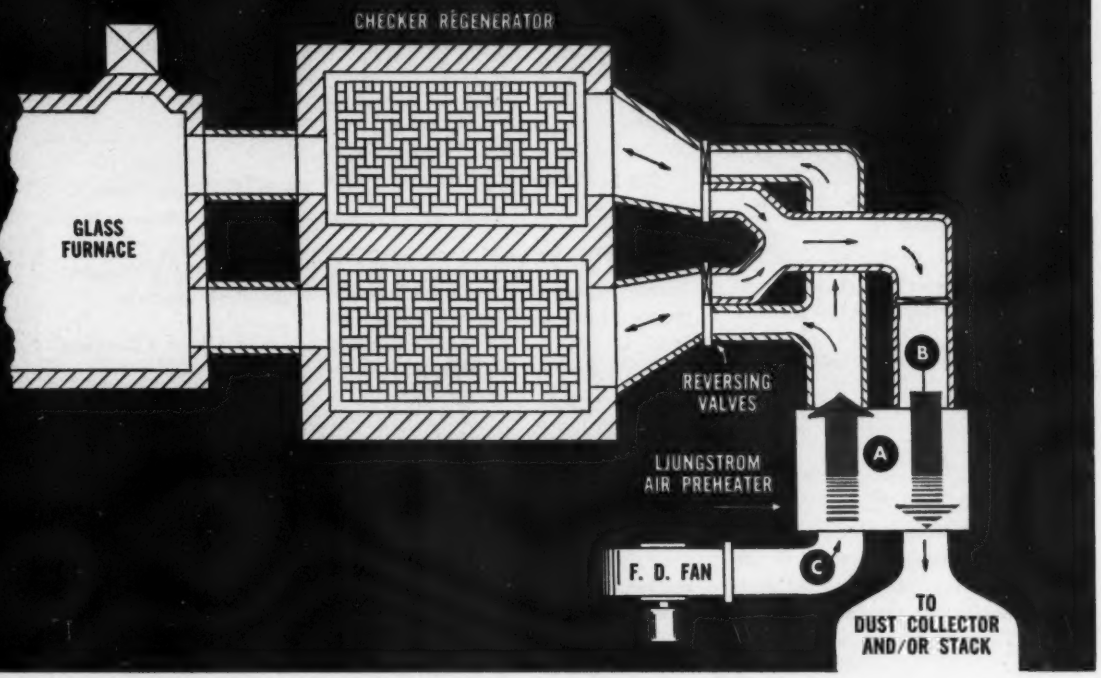
Although the spray-up systems have simplified the application of reinforced plastics, they are not entirely free from certain inherent disadvantages. In order to spray successful laminates, all three components of the system—resin, catalyst and reinforcement—must be in proper balance. While the initial set-up of the three components is relatively simple, the ratios and adjustments must be frequently checked to prevent undercured parts or low strength areas. The resin system equipment usually requires daily cleaning to operate efficiently.

Swimming pool coated with fiber glass. Tank in background contains promoted and catalyzed resin; fiber glass leads from can to gun.

As in all spray systems, even the best equipment is no better than the operator. If the spray pattern is not uniform, variable thicknesses are produced which can result in erratic part performance. Because the actual spraying is of utmost importance, many of the equipment manufacturers offer training courses. These courses instruct the user in the calibration, operation, and maintenance of the system.

Spray equipment is a versatile new tool of the reinforced plastics industry and is definitely making a place for itself among the older fabricating methods. However, its use must still follow sound engineering practices, and the resulting products must meet the same performance tests established for the industry. With this in mind, the spray-up guns will open new vistas for reinforced plastics when used with imagination and enterprise.

First rotary metallic heat exchanger for the Glass Industry expected to produce 11-13% fuel savings a year



The Ljungstrom Air Preheater is the most efficient metallic heat exchanger ever developed. *Every* major utility in the U.S. is equipped with Ljungstroms for heat recovery. Major reason for Ljungstrom efficiency is the patented rotary regenerative counterflow principle where heat is absorbed by, and released from, the same metal surface. The entire heat exchange surface (A) rotates, continuously absorbing heat from exhaust gas (B) and releasing it into incoming air (C).

The first Ljungstrom® rotary regenerative air preheater installed in a glass plant primarily for heat recovery purposes is scheduled to go into operation this September.

Purchased by a leading glass manufacturer for use on an existing plate glass tank, the Ljungstrom is designed to raise the temperature of the incoming combustion air to the brick regenerator from 80°F to about 950°F.

This performance was based on extensive testing by both the glass manufacturer and the Air Preheater Corporation — with testing conditions fully representative of actual production conditions. On this basis, the projected annual fuel savings are estimated at 11-13%. It is expected that the capital outlay for the unit will be recovered within eighteen months and additional savings are anticipated from increased checker life, better glass quality, and higher tank tonnage.

For full information on what a Ljungstrom can do in your plant, with your equipment, contact:

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N.Y.

NEWS
IN THE GLASS INDUSTRY

The first of an annual series of seminars for the accreditation of scientific glassblowers was held recently at the College of Ceramics, Alfred University. Discussing the program are, (l. to r.) Dr. T. J. Gray and Dean John F. McMahon, both of the college, J. Allen Alexander, president, American Scientific Glassblowers Society, and Howard M. Nutt, chairman of the society's standards committee.

The Corning Museum of Glass

MICHAEL MILKOVITCH appointed curator of collections, succeeding DR. AXEL VON SALDERN who is now curator of painting and sculpture at the Brooklyn Museum.

Pittsburgh Plate Glass Co.

JOHN B. WHITE appointed general manager of window glass plants, succeeding WALTER G. KOUPAL who will retire from that post January 1, 1962 . . . ROBERT C. PERRY will succeed White as manager of Works 1, Creighton, Pa. . . . W. F. NEWTON assigned to the newly-created post of director of marketing planning for the merchandising division. He will be succeeded as director of sales for the chemical division (formerly Columbia Southern Chemical Corp.) by PAUL A. FODOR, JR., formerly assistant director of sales . . . PPG is supplying the curved side windows for Ford Motor Co.'s Thunderbird and Lincoln cars. Shipment for this new order began in August from Works 26, Crestline, O., and are expected to amount to some 600,000 units for an estimated 100,000 cars in the production runs of the 1962 lines.

Jeanette Glass Co.

The McKee Div. of Thatcher Glass Mfg. Co. has been purchased by Jeanette for an undisclosed price believed to be well over $4 million in cash, stock, and notes. Both company's plants are located in Jeanette, Pa., but Jeanette plans to consolidate the entire operation at the McKee plant in the near future. The merger, subject to the approval of Thatcher stockholders, adds a Thatcher representative to the Jeanette board of directors.

Arthur W. Schmid International

ARTHUR W. SCHMID, executive head of the company, which has its headquarters in Pittsburgh, Pa., has announced that the firm's 25th anniversary will be celebrated this year. Schmid International was formed recently to meet Arthur W. Schmid Co's expanded activity in glass plant engineering, design, construction, and operation.

Emhart Mfg. Co.

WALTER B. MC KINNEY named general manager of the firm's Hartford division. He was previously division general sales manager . . . KENNETH R. GECKLER appointed manager of the division's West Coast operations, with headquarters in Anaheim, Calif.

Borax To Sell Vitro Products

U. S. Borax Chemical Corp. and Vitro Chemical Co. have signed a marketing agreement according to which Borax will exclusively distribute Vitro rare earth products to the glass and ceramics industries in the United States, Canada, and Mexico. Vitro will continue to market these chemicals to industries not normally served by Borax . . . Vitro has moved its marketing department to new quarters at 261 Madison Ave., consolidating the company's New York operations.

Kimble Glass Co.

An automatic paste mold glassblowing machine, the largest of its type in the world, has been put into production at the company's Vineland, N. J. plant. The machine itself is three stories high, cost $1.5 million to build and will be used in the manufacture of "Kimex" scientific glassware.

Allied Chemical Corp.

PAUL B. CORNELL named assistant manager of the Solvay Process Div. plant at Moundsville, W. Va. He formerly held the same post at the division's Brunswick, Ga., installation.

Owens-Illinois Glass Co.

JAMES W. HACKETT made administrative vice-president and director of engineering. Presently director of research, he assumes this additional responsibility in succeeding ELLIOT R. OWENS who has been transferred to the position of vice-president, production, for the Forest Products Div.

John B. White

Arthur W. Schmid

Walter B. Mc Kinney

James W. Hackett

Vitro Chemical Company is pleased to announce that U. S. Borax will be its exclusive sales agent for rare earth chemicals to the glass and ceramic industries.

Vitro CHEMICAL COMPANY
a division of Vitro Corporation of America
261 MADISON AVENUE • NEW YORK 16, NEW YORK

U.S. BORAX
630 SHATTO PLACE, LOS ANGELES 5, CALIFORNIA

NEW APPLICATIONS IN GLASS...

Artist's conception of how "Comfor-Lite" would appear in window overlooking skyline.

New Horizons in Architectural Glass

As a result of intensive efforts on the part of glass manufacturers and construction engineers to overcome the problems of light, sound, heat, glare, and mechanical strength, glass has gradually been transformed into one of the most sophisticated and dramatic materials available to the building industry. The many new types of glass and curtain wall systems which have come on the market—some of them just within the past few months—are having a profound influence on interior decoration as well as on exterior building design. Their emergence marks the advent of tradition-shattering and, quite often, cost-saving concepts in handling architectural glass.

● A glare-reducing glass called "Comfor-Lite" features a horizontal screen, composed of thousands of tiny louvers, sealed between two panes of glass to form a single, self-shading glazing unit. The louvers are spaced and tilted at a permanent angle which assures maximum screening-out of heat and glare. The arrangement is consistent with the sun's angle on the horizon, yet allows virtually unobstructed outward visibility. (For the 17-louver-to-the-inch screen, the manufacturer claims an 89 per cent shading efficiency and 84 per cent outward visibility.) The effectiveness of this glass-and-screen "sandwich" in blocking heat and glare (temperatures during summer have been reduced 15°F) has been proved by substantial savings in air conditioning costs.

Another glare-reducing glass, "Twi-Lite," is constructed with a gray interlayer which acts as a filter to absorb solar energy. (See THE GLASS INDUSTRY, *42*, 7, 399.) This filter allows just enough energy to penetrate to provide adequate daylight, and the excess energy, or glare, is split up—half outward, half inward. Energy-absorbing efficiency of this glass is said to be 60 to 80 per cent higher than that of conventional clear glass.

With the availability of these two types of glass, the architect need no longer sacrifice his aesthetic sense of flush symmetry to the necessity for shading devices such as concrete overhangs, extension screens, and awnings. Furthermore, the interior decorator may find that the function of draperies, blinds, and shades has been eliminated by the very element which they have been designed to cover.

In the area of sound control, "Acousta-Pane" (see THE GLASS INDUSTRY, *42*, 7, 399) offers visibility and natural daylight in applications where these two factors formerly had to be sacrificed for sound privacy. Normally, glass vibrates in response to sound waves and transmits these vibrations as noise, but this specially laminated glass contains an interlayer which converts sound energy into tiny amounts of heat instead of passing it through the pane as noise. Peak effectiveness centers in the 1500 to 400 cycles-per-second frequency range, covering the most common of the distracting sounds which penetrate ordinary glass. The result is a 66 per cent reduction of the noise intensity level, an important consideration in factory and hospital construction where interiors have long been dimmed by the bleak confinement of solid walls. *Amerada Glass Corp.*

Reader Service Card: Circle No. 50

● A conventionally-ground glass, called "Grey Plate" has been introduced for efficient control of heat and glare through large areas in homes and commercial buildings. Manufactured in 13/64-in. thickness, this new product has a pleasing grey color, yet permits objects viewed through the glass to be seen in their natural color. It transmits approximately 50 per cent of average daylight and 52.2 per cent of total solar radiation. The glass, which features ground and polished reflective surfaces, is available in sizes up to a maximum of 84 in. by 120 in., and is priced competitively. *Libbey-Owens-Ford Glass Co.*

Reader Service Card: Circle No. 51

● A new glass spandrel for curtain wall construction features a polished glass outer surface with metallic-faced inner surface. By combining this polished panel a nonreflective patterned glass panel, the architect can capitalize on the advantages of the curtain wall system, and at the same time, vary the appearance and add an impression of depth. Where a polished glass panel is desired, the metallic aluminum backing provides insulation by reflecting heat. *American-Saint Gobain Corp.*

Reader Service Card: Circle No. 52

● For better residential and light commercial construction, a new sliding glass door has been engineered for exceptional strength and rigidity. Called the "Monterey," it features the use of tabular extrusions for all intersecting frame members. The door is designed for either 3/16-in. or ¼-in. sheet glass and can also accommodate ⅝-in. dual glazing. Field or shop glazing is permissible. *Ador Corp.*

Reader Service Card: Circle No. 53

● A new type of glass construction, the "Jalwal," affords maximum ventilation while insuring security. The unit includes fully screened and weatherstripped jalousies and an aluminum sliding glass door. It is easy to install and can be used in floor-to-ceiling or knee-height window applications. Porches, breezeways, additions, summer rooms, and, in particular, bedrooms where ventilation and security are essential, are areas for which the "Jalwal" is ideally suited. *Acorn Aluminum Products Co.*

Reader Service Card: Circle No. 54

HANDBOOK OF GLASS MANUFACTURE

3rd Printing BY DEMAND

VOLUME I A valuable reference for the glass man, containing basic material on . . . CHEMICAL MAKEUP OF GLASS . . . PHYSICAL PROPERTIES (brittleness, resiliency, hardness, thermal expansion, etc.) . . . RAW MATERIALS . . . BATCH MATERIALS HANDLING AND PREPARATION . . . FURNACES AND FUELS (fuel and combustion data and calculations; fuel economics, heat losses, draft and chimneys; glass-melting furnaces) . . . INSTRUMENTATION (temperature, pressure, flow, level, and speed control; forming operations; lehrs) . . . REFRACTORIES . . . GLASS PREPARATION (types of reaction; melting, fining, homogenizing; detection of cords; density, etc.) . . . FEEDING AND FORMING (gob feeder; blow-and-blow, IS, press-and-blow, paste mold, and bulb machines; hand processes; forming defects; viscosity; bottle shape, design, and weight) . . . ANNEALING AND TEMPERING (release and strain; annealing equations; annealing of plate glass, optical glass, and pressed and blown ware; special problems in tempering flat glass) . . . GLASS DECORATING.

VOLUME II First Printing (Published in 1960)

Order your copies of Volume I and Volume II NOW.

OGDEN PUBLISHING COMPANY
55 West 42nd St.
New York 36, N.Y.

Please send me The Handbook of Glass Manufacture

_____copy(ies) Volume I (506 pages) $15.00* per copy

_____copy(ies) Volume II (276 pages) $10.00* per copy

*Shipping and handling charges: 60¢ per copy (domestic)
90¢ per copy (foreign)

Foreign remittance in U. S. Dollars.

(Order for 5 or more copies, 10% discount).

Amount enclosed $_____.

Name _____

Company _____

Street _____ City _____ State _____

CONTENTS . . .

OPTICAL PROPERTIES
N. J. Kreidl, *Bausch & Lomb Incorporated*

EFFECTS OF HIGH ENERGY RADIATION
N. J. Kreidl, *Bausch & Lomb Incorporated*

CHEMICAL ANALYSIS OF GLASS
Frances W. Glaze, Consultant
John Tims, *Owens-Corning Fiberglas Corp.*

THE QUALITY CONTROL CHART
Ronald Wiley*, *Owens-Corning Fiberglas Corp.*

SCIENTIFIC GLASSBLOWING: GLASS FABRICATION
Vincent DeMaria,† *Glass Products Development Laboratory*

GLASS COMPOSITION, DEVITRIFICATION AND STRUCTURE
Fay V. Tooley, *University of Illinois*

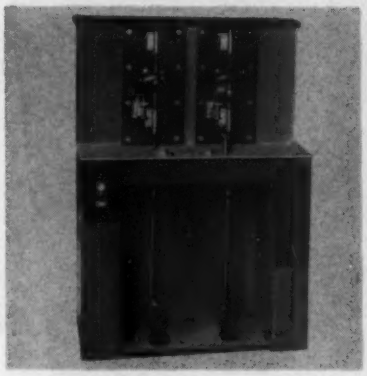
FLAT GLASS MANUFACTURING PROCESS
Roy G. Ehman, *Pennsylvania State University*

ELECTRIC MELTING OF GLASS
Larry Penberthy, *Penberthy Electromelt Co.*

*Now with Deering Milliken Research Corp.
†Now with Thermal America Fused Quartz Co.

Both volumes have been edited by Fay V. Tooley, professor of glass technology, University of Illinois. Every chapter has been written by an authority in the field. These detailed reference books have an important place in the laboratory and on the desk of every glass man. They are basic, authoritative, comprehensive.

NEW EQUIPMENT AND SUPPLIES



High-Frequency Sealing Machine

Glass-to-metal seals, composed of three metal parts with two glass pieces in between, can now be made, simultaneously, in one operation. The 2-position machine for making these high-frequency seals is regulated by a precision timer control unit, and both positions can be used alternately and for different assemblies. The operation itself takes about 8 seconds. *Kahle Engineering Co.*

Reader Service Card: Circle No. 55

Heat-Resistant Identification Tags

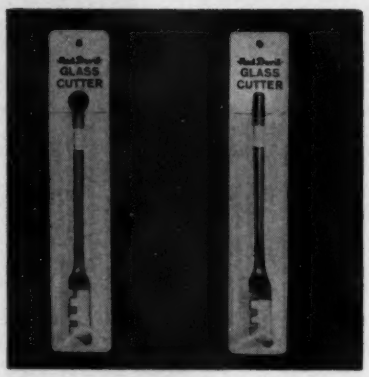
Tags of over 100 different shapes, easily recognized at a glance, allow manufacturers and users to distinguish between closely allied materials, parts, and equipment. Called "Eve-Dent Tags," they are available in both metal and plastic, and in a variety of colors. Each one has its own predetermined meaning, and is unaffected by extreme heat or weather conditions. *Broomall Industrial Sales Co.*

Reader Service Card: Circle No. 56

Cerium Oxide Mirror Polish

New low-price compound speeds production and reduces unit costs. The cerium oxide polish, called "Vitrox 500," has been extensively field-tested by mirror companies, and is said to reduce rejects and scratch polishing and to produce better surfaces. It is also effective in blocking and beveling. *Vitro Chemical Co.*

Reader Service Card: Circle No. 57



New Glass Cutter

Cuts freely without any trace of wheel drag or wobble, according to the manufacturer. A nylon axle, saturated with lubricant, and a micromachined wheel slot eliminate these two problems, insuring high-quality cuts. *Red Devil Tools.*

Reader Service Card: Circle No. 58

Glass Gripper Glove

Exceptionally cut- and abrasion-resistant, this new glove offers an added measure of safety in the handling of glass. "Box-tip" fingers increase both comfort and protection, and the fabric, claimed to be very flexible and long-wearing, provides an excellent grip on dry, slick surfaces. *Advance Glove Mfg. Co.*

Reader Service Card: Circle No. 59

Carbide-Tipped Masonry Drills

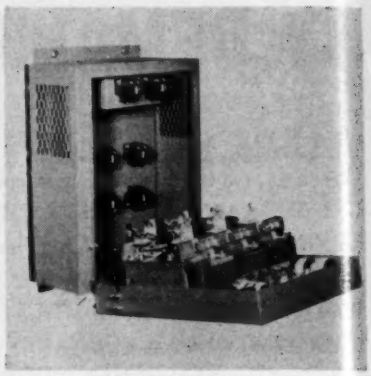
Feature specially designed grooves in the flutes for removal of dust and particles which cause clogging and overheating. Mounting of carbide tips in tempered steel shafts is said to provide faster, easier cutting and longer wear. *Danish Import.*

Reader Service Card: Circle No. 60

Electric Furnace Temperature Control

A proportional power magnetic amplifier has been developed for precise electrical control applications. Tested in a glass melting operation, it has held temperatures within 0.1°C at 1400°C. *Hevi-Duty Electrical Co.*

Reader Service ard: Circle No. 61



Static Control for Electric Furnaces

An arc-free static control, with no moving parts to wear out, has been developed for heat control in the glass industry. In comparison with the commonly-used 3-phase saturable core reactor, this new device is said to represent an 86 per cent reduction in size and a 95 per cent reduction in weight. *Westinghouse Electric Corp.*

Reader Service Card: Circle No. 62

CATALOGS RECEIVED

Evaluation of diamond grit performance (DIAMOND DATA, Vol. II, No. 1). Covers the selection of the diamond grit best suited for a specific grinding application. Achievement of higher performance levels requires the consideration of numerous variables because there are now so many different types of grit available. *Englehard Hanovia, Inc.*

Reader Service Card: Circle No. 63

Closed-circuit TV for science and industry (10 pages). Tells how closed-circuit TV can expedite surveillance, transportation. dispatching, cost reduction, quality control, merchandising, security, and the observation of hazardous areas. *Fairbanks, Morse & Co.*

Reader Service Card: Circle No. 64

Scale error (8 pages). Causes and corrections are outlined in a booklet covering step-by-step procedure, equipment, service program, costs. *Howe Scale Co.*

Reader Service Card: Circle No. 65

INVENTIONS AND INVENTORS

Glass Wool and Fibers

Metal Applicators for Glass Filaments. Patent No. 2,980,956. Filed December 2[illegible] 1953. Issued April 25, 1961. One sheet of drawings; not reproduced. Assigned to Owens-Corning Fiberglas Corp. by Harry B. Whitehurst, William H. Otto, and William P. Warthen.

The coating of glass fibers with such metals as zinc, aluminum, tin, lead, and alloys of zinc and aluminum, has been found highly advantageous in protecting the wear-sensitive surfaces of the glass fibers. It also increases their working strength in strands, yarns, cords, ropes, fabrics, and other textile products, as well as in products such as fibrous mat, wool, and structural boards. This invention provides a new method and means for continuously applying metal to glass fibers during fiber-formation, which permits stable high-speed production with a minimization of nonuniformities in the final product and discontinuities in forming operations.

The fibers are drawn from streams supplied from outlets in a platinum feeder associated with a source of molten glass such as a melting tank. The fibers are drawn over a roll-type size applicator, at which sizing material such as petroleum oil, vegetable oil, gelatine, and starch or the like may be applied before the fibers are gathered into strand form. The freely rotatable spinner-type gathering member is made of material such as graphite or Teflon. A strand is formed of gathered glass fibers which are wound on a collection tube to produce a package of desired form.

Metal is applied to the glass fibers by a metal applicator unit located between the feeder and the size-applicating roll. It is positioned at a level determined by the type of metal to be applied to the glass, and at which the glass fibers are of a temperature which will produce the desired properties in the metal-coated fibers. The applicator unit is generally a container for molten metal, and is made of suitable high-temperature materials to withstand the heat of the metal.

Two claims and 16 references.

Miscellaneous

Method of Sealing Glass to Other Elements. Patent No. 2,977,722. Filed March 5, 1959. Issued April 4, 1961. One sheet of drawings; not reproduced. Assigned to Pittsburgh Plate Glass Co. by Renato J. Mazzoni.

In sealing glass to other elements, the various parts are assembled in juxtaposition at room temperature, and then transferred to heating zones where they are heated to be sealed together. Frequently, the parts to be sealed move, relative to each other, between the times of assembly and sealing. This relative movement may be caused during transportation of the assembly to the heating furnaces, or in the heating furnaces. It may also occur as a result of thermal expansion of the parts during the heating prior to sealing. Such relative movement of the parts results in improper alignment and fusion of the parts, and consequently, rejection of the completed article.

By employing a combination of a polybutene and a low softening point glass, it is possible to maintain the elements in place during the various transportation steps between the time of assembly and sealing of the respective parts of the structure. The polybutene is tacky and adhesive at room temperature, and serves to adhere the glass and other elements in their assembled position at room temperature during transportation to the heating zone and also during the preliminary heating of the assembly in the heating zone. The polybutene burns off at a temperature just below the softening temperature of the low softening point glass and prior to the sealing of the parts. The polybutene leaves no residue and in no way impairs the formation of a good seal.

There were four claims and the following references.

United States Patents

1,190,242, Hill, July 4, 1916; 2,562,163, Hiensch *et al.*, July 31, 1951; 2,593,507, Wainer, April 22, 1952; 2,686,342, D'Eustachio, August 17, 1954, and 2,768,475, Seelen *et al.*, October 30, 1956.

Sheet and Plate Glass

Method and Apparatus for Bending Glass. Patent No. 2,967,378. Filed December 9, 1958. Issued January 10, 1961. Two sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Co. by Richard W. Jones and Lloyd V. Black.

This invention pertains to a method and apparatus for bending glass sheets upon curved shaping molds. A glass sheet is subjected to a sequence of different heat patterns while supported on a mold having a curved shaped surface, which may be either convex or concave in elevation. The first heat pattern applies only general heat to the entire glass sheet with only sufficient intensity to bring the glass sheet to approximately its softening point. The end portions of the glass sheet begin to deflect and its central portion conforms to the central portion of the shaping surface.

Intense localized heat is then applied to a first portion immediately outboard of the portion that has conformed to the shaping surface, and discontinued when the first portion has conformed to the shaping surface. Then, a second portion immediately outboard of the enlarged portion already contacting the shaping surface is heated intensely until it, too, contacts the shaping surface. The localized heating of the second portion is discontinued, and local intense heat is sequentially applied and discontinued in successive outboard portions of the glass sheet until the entire glass sheet conforms to the shaping surface. The general heating is continued during the sequence of localized treatments.

There were 15 claims and the following references.

United States Patents

2,111,392, Galey, March 15, 1938; 2,176,999, Miller, October 24, 1939; 2,348,905, Hopfield, May 16, 1944; 2,450,297, Pearse *et al.*, September 28, 1948; 2,646,647, Bamford *et al.*, July 28, 1953; 2,671,987, Jendrisak, March 16, 1954, and 2,671,988, Walters, March 16, 1954.

(*Continued on page* 601)

•CALENDAR•
OF COMING EVENTS

October 10

ACS PITTSBURGH SECTION. A joint meeting to be held with the Pittsburgh Ceramic Association. Pittsburgh, Pa.

October 11-13

ACS GLASS DIVISION. Fall meeting. H. E. Simpson, program chairman. Bedford Springs, Pa.

October 16-19

INTERNATIONAL CONGRESS ON VACUUM TECHNOLOGY. Sheraton Park Hotel, Washington, D. C.

October 19-20

16th MIDWEST QUALITY CONTROL CONFERENCE. Chase-Park Plaza Hotel, St. Louis, Mo.

October 25-28

ACS 14TH PACIFIC COAST REGIONAL MEETING. Jack Tar Hotel, San Francisco, Calif.

November 27-December 1

28TH EXPOSITION OF CHEMICAL INDUSTRIES. New York Coliseum, New York, N. Y.

November 30-December 1

22ND ANNUAL CONFERENCE ON GLASS PROBLEMS. For further information concerning the conference, contact F. V. Tooley, professor of glass technology, 208 Ceramics Building, University of Illinois, Urbana, Ill.

February 11-14, 1962

CANADIAN CERAMIC SOCIETY. Diamond Jubilee Meeting. Royal Connaught Hotel, Hamilton, Ontario, Canada.

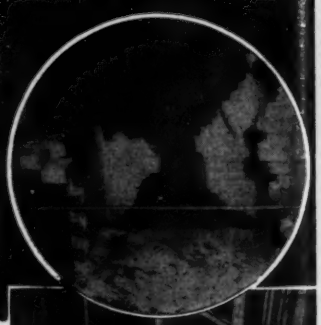
April 29-May 3, 1962

ACS 64TH ANNUAL MEETING. Roosevelt, Commodore, and Biltmore Hotels, New York, N. Y.

July 8-14, 1962

SIXTH INTERNATIONAL CONGRESS ON GLASS. Washington, D. C.

Why Not MODERNIZE when you next shut down for REPAIRS?



TECO

EXPERIENCE and COUNSEL will assure Top Results!

Periodic shutdown for repairs are inevitable. But manufacturers can anticipate them—contact TECO engineers and exchange views as to objectives and possibilities for modernization and basic improvements.

Then, drawing upon their vast and diversified experience, TECO engineers can develop the plans and make provisions to "move in" at the right time.

Thus, changes can be made with minimum delay and expense; and the end result will be a strictly modern plant that will run more smoothly, reduce costs and put the owners in a more favorable position to meet competition.

A consultation as to possibilities will entail no obligation.

Photos showing repair and modernization operations on a port and uptake while a temperature of 2500 degrees was maintained in the adjacent port.

TOLEDO ENGINEERING Company INC.

Phone GReenwood 5-1529

3003 SYLVANIA AVENUE, TOLEDO 13, OHIO

CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during June, 1961 was as follows. *Flat Glass*: a preliminary figure of 23,200 for June, 1961, indicates a decrease of 0.4 per cent from the figure of 23,300 given for May, 1961. *Glass and Glassware, Pressed and Blown*: an increase of 0.2 per cent is shown by the preliminary figure of 88,400 reported for June, 1961, when compared with the adjusted figure of 88,200 reported for May, 1961. *Glass Products Made of Purchased Glass*: the preliminary figure of 12,800 given for June, 1961, is 0.7 per cent over the figure of 12,700 reported for May, 1961.

GLASS CONTAINER SHIPMENTS
(All Figures in Gross)

Narrow Neck Containers

	July, 1961
Food	1,316,000
Medicinal and Health Supplies	1,099,000
Chemical, Household and Industrial	797,000
Toiletries and Cosmetics	814,000
Beverage, Returnable	969,000
Beverage, Nonreturnable	300,000
Beer, Returnable	250,000
Beer, Nonreturnable	1,729,000
Liquor	743,000
Wine	307,000
Subtotal (Narrow)	8,324,000

Wide Mouth Containers

Food	*3,886,000
Medicinal and Health Supplies	328,000
Chemical Household and Industrial	132,000
Toiletries and Cosmetics	242,000
Dairy Products	114,000
Subtotal (Wide)	*4,702,000
Total Domestic	13,026,000
Export Shipments	*117,000
TOTAL SHIPMENTS	*13,143,000

* This figure includes fruit jars, jelly glasses, and packers' tumblers.

GLASS CONTAINER PRODUCTION AND INVENTORY
(All Figures in Gross)

		Production July 1961	Stocks July 1961
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics.	Narrow Neck	4,800,000	8,030,000
	Wide Mouth	*5,348,000	*7,788,000
Beverage, Returnable		832,000	2,286,000
Beverage, Nonreturnable		358,000	721,000
Beer, Returnable		270,000	515,000
Beer, Nonreturnable		1,816,000	1,255,000
Liquor		869,000	1,642,000
Wine		363,000	833,000
Dairy Products		123,000	301,000
TOTAL		*14,656,000	*23,070,000

* This figure includes fruit jars, jelly glasses, and packers' tumblers.

Payrolls in the glass industry during June, 1961 were as follows. *Flat Glass*: a decrease of 0.2 per cent is shown by the preliminary figure of $12,555,647.44 given for June, 1961, when compared with the adjusted figure of $12,576,216.19 given for May, 1961. *Glass and Glassware, Pressed and Blown*: an increase of 1.1 per cent is shown in the preliminary $36,557,070.37 given for June, 1961, when compared with the previous month's adjusted figure of $36,148,051.94. *Glass Products Made of Purchased Glass*: a preliminary figure of $4,347,697.54 was reported for June, 1961. This is an increase of 2.8 per cent when compared with the adjusted figure of $4,227,335.46 for May, 1961.

Glass Container Production based on figures released by the Bureau of Census, Industry Division, was 14,656,000 gross during July, 1961. This is a decrease of 3.8 per cent from the previous month's production figure of 15,243,000 gross. During July, 1960, glass container production was 14,224,000 gross, or 2.9 per cent less than the July, 1961 figure. At the end of the first seven months of 1961, glass manufacturers have produced a preliminary total of 97,542,000 gross. This is 2.6 per cent more than the 95,061,000 produced during the same period in 1960.

Glass Container Shipments during July, 1961, came to 13,143,000 gross, a decrease of 16.7 from the June, 1961, figure of 15,785,000 gross. Shipments during July, 1960, amounted to 12,801,000 gross, or 2.6 per cent less than July, 1961. At the end of the first seven months of 1961, shipments have reached a preliminary total of 94,175,000 gross. This is 4.6 per cent more than the 90,029,000 gross shipped during the same period of the previous year.

Stocks on Hand at the end of July, 1961, came to 23,070,000 gross. This is 6.6 percent more than the 21,657,000 on hand at the end of June, 1961, and 4.2 per cent more than the 22,134,000 on hand at the end of July, 1960.

Flat Glass Imports for the first half of 1961 declined 14.7 per cent under the same period in 1960. Belgium continued as major exporter to the U.S. ($9.6 million), supplying 42.3 per cent of the total.

FLAT GLASS IMPORTS BY TYPE*
(First 6 Months)

	1961	1960
Cylinder, Crown, and Sheet	$11,796,699	$14,801,866
Plate	8,567,066	8,814,328
Mirror	274,416	433,473
Rolled	1,701,943	2,080,106
Laminated, etc.	325,416	440,155

*Consumer Durables Division, Business and Defense Services Administration

A Key Chemical for the glass industry since 1890

Wyandotte Soda Ash

We're always looking at the glass industry from your viewpoint: how to get more people to utilize to the fullest extent the wonderful characteristics of glass.

WYANDOTTE CHEMICALS

MICHIGAN ALKALI DIVISION, WYANDOTTE, MICHIGAN

Founded by a Glassmaker to Serve the Glass Industry

NEW BOOKS

MODERN ASPECTS OF THE VITREOUS STATE, VOLUME I. Edited by J. D. Mackenzie, General Electric Research Lab. Schenectady, N. Y. Butterworth Inc., Washington, D.C. 226 pages. $9.50.

Some general aspects of glasses are discussed in Chapter 1, while the second chapter is concerned with the present status and limitations of X-ray diffraction as a tool in the investigation of glass structure. In Chapters 5 and 6, respectively, two other tools are dealt with: nuclear magnetic resonance and infrared absorption. Chapter 3 summarizes question of kinetic barriers to crystalization as liquids are super-cooled. Chapter 4 contains a discussion on the constitution of phosphate glasses, based primarily on results obtained from a different approach—that of aqeous solution techniques. The theoretical aspects of glass transition which differentiates a liquid from a glass is covered in Chapter 7, while Chapter 8 reviews the structures of a number of inorganic glass-forming liquids such as the simple oxides and halides.

ARBITRATION OF LABOR DISPUTES. By Clarence M. Updegraff and Whitley P. McCoy. The Bureau of National Affairs, Inc. Second Edition. 321 pages. $8.50

A few parts of the first edition, published in 1946, have been eliminated from this volume, and the rest of the book has been brought up to date with the discussion of recently developing trends, beliefs, and practices, and the results of labor arbitration. The author has presented analyses of recent statues and decisions of boards and courts which he feels will affect the expansion and direction of labor arbitration development in the immediate future. Three new chapters have been added: "Summary of Labor Laws and Policy," "Arbitration and Various Areas of Employment," and "The Legal Rules of Evidence."

1961 PRODUCT DIRECTORY OF THE REFRACTORIES INDUSTRY IN THE UNITED STATES. Order from The Refractories Institute, First National Bank Building, Pittsburgh 22, Pa. 224 pages. $4.50

A listing of 3548 different brands of refractories, representing an increase of 24 per cent over the number in the previous directory published in 1958. The directory gives a company-by-company breakdown of products covering 170 producers, or almost the entire $400-million-a-year industry. The four sections of the directory list *(1)* manufacturers' names and addresses, *(2)* plant locations by state and city, *(3)* divisions of the industry, with a breakdown of manufacturers making each type of refractory, and *(4)* a complete list of trade names.

Books of all publishers are available through THE GLASS INDUSTRY *book department.*

MARGIN IN PLANT SAFETY?

(*Continued from page* 566)

and literature on the subject for employees. Topics involving the home and highway are chosen for departmental meetings. Some plants have scheduled mailings of O-T-J literature to employees' homes. Frequently a plant manager's letter will accompany booklets which tell how home and driving accidents can be avoided. The plant also subscribes to the National Safety Council's quarterly magazine, *Home Safety*, which is mailed directly to each employee's home.

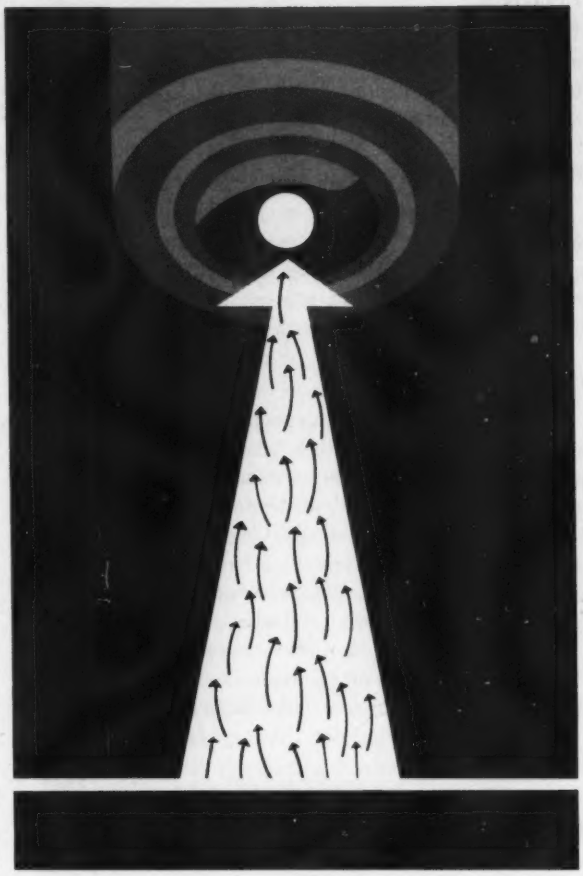
In its continuing efforts to promote O-T-J safety, officials at the Cumberland plant held a "Family Safety Fair" for plant employees and their families in 1960. This novel idea met with popular success; nearly 400 wives and children attended. Several exhibits of safety clothing and equipment (Fig. 4), emphasis on highway and home accident facts, and other appropriate displays stressed the need for accident prevention in areas other than the plant. A similar meeting is now being planned for 1961.

Unquestionably, activities such as these pay off in less absenteeism and reduced insurance costs. Yet these savings are insignificant when compared to suffering and loss of wages which can be eliminated when O-T-J accidents are prevented. Furthermore, the modern plant can ill afford to train skilled workmen to take the place of the injured. Table I gives a comparison of one plant's accident record with outside injuries to employees. It is evident that employees are four times safer at work than at home, and that injuries incurred during working hours are six times less severe than those sustained off the job. This fact alone is sufficiently significant to warrant intensified efforts to eliminate off-the-job accidents.

TABLE I—First 3 Months of 1961

Plant Frequency per Million Hours Worked	O-T-J Frequency per Million Hours Exposure
1.7	6.9
Plant Severity per Million Hours Worked	**O-T-J Severity per Million Hours Exposure**
37	227

We must never be satisfied with our safety records and achievements. Regardless of the numerous National Safety Council Awards of Honor that a plant receives and the lengthy work periods free from disabling plant injuries, employees cannot afford to relax for a minute their determined efforts to improve safety attitudes. The old cliche about going backward if we do not go forward is particularly true in safety. Plant safety personnel know that a good safety program must be maintained at all times, and what is most important, that there must be a relentless search for effective ways to keep employees and plant management on the alert in the never-ending battle with accidents.



FOR DEPENDABLE GLASS
SURFACE
TEMPERATURE...

Here's the industry-proved Rayotube® radiation pyrometer that effectively detects "skin" temperatures on flat or plate glass—whether stationary or moving—in the working range of 400 to 1400 F. Mounted to sight directly onto the surface of the glass from a distance, the L&N Glass Surface Rayotube senses surface radiation . . . produces a continuous, reliable indication of surface temperature virtually independent of glass-thickness.

For detailed information on the L&N Glass Surface Rayotube, or to investigate other areas of L&N's complete instrumentation systems for glass plants, call your nearest L&N office, or write 4901 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP
Pioneers in Precision

Reader Service Card: Circle No. 27

LITHIUM

(*Continued from page* 570)

material needs. Spodumene, however, could be substituted for a substantial portion of the lepidolite as the raw material at this operation.

Strategic Considerations and Defense Program

Lithium compounds have several essential uses in the defense program. It is not, however, on the list of strategic and critical materials to be acquired for the national stockpile. The mines and processing facilities for this commodity are well dispersed throughout the nation.

Prices

The principal lithium compounds, lithium carbonate and lithium hydroxide, sell for about 67 and 72 cents a pound, respectively. Prices on these two compounds and other lithium compounds can be found in the issues of *Oil, Paint & Drug Reporter*. Lithium mineral prices, however, are seldom quoted in trade journals. The September, 1955, issue of *Engineering & Mining Journal* gave the following prices on lithium minerals, f.o.b. the mine (subject to negotiation): spodumene 6 per cent Li_2O, $11 to $12 a short ton unit; amblygonite, $60 to $75 a short ton; lepidolite (hand picked), $11 to $12 a short ton unit; and petalite, hand picked, $11 a short ton unit.

Lithium metal, 99.5 per cent pure, was quoted at $9 to $11 a pound in *E&MJ*, "Metal & Mineral Markets." The prices of the principal lithium compounds have remained relatively stable during the past 20 years, despite the financial inflation that occurred during that period. Improvements in technology and increases in production capacities have decreased production costs which counterbalanced inflationary influences. The average value per ton of lithium minerals and compounds shipped from mines can be found in Table II.

Tariff

Lithium minerals are imported duty-free. Lithium metal is dutiable at 25 per cent ad valorem. Lithium compounds are dutiable at 12.5 per cent ad valorem.

Research

The lithium industry is an excellent example of what can be accomplished in developing new uses for minerals in plentiful supply. Lithium, which only a few years ago was a little known and little used material, now is the foundation of a multimillion-dollar industry. It has many essential military applications and fills a variety of important civilian requirements.

Research on lithium has undergone several phases. Before World War II, few uses had been developed for this commodity and most of the meager research was directed toward the development of markets. The war brought a surge of demand, and the industry concentrated its effort on expanding capacity with some research on technology intended primarily to increase output. It was during the period immediately preceding the war and in the early war years that the Bureau of Mines concentrated research on the recovery of lithium from its various ores. After the war and the loss of military markets, emphasis in end-use research led to development of significant new uses. Demand gradually outgained productive capacity. Industry rushed to build additional facilities and reverted to research on improved technology, with both government and private research groups participating. Once again, partly because of successful research, the lithium production capacity reached a volume greater than requirements.

Government, private research organizations, and industry are currently doing research on new products and studying their properties, developing new applications, improving technology of recovery and processing, and improving the economics of recovery of coproducts. The domestic lithium industry, late in 1956, formed the American Lithium Institute, Inc., with headquarters at Princeton, N.J., to develop new applications of lithium products and disseminate information in lithium and its compounds. The institute was disbanded in mid-1958.

Outlook

It has become increasingly evident that the lithium resources of the world are adequate to supply foreseeable needs and that lithium producing facilities are presently ample and could be greatly expanded if necessary. The outlook at present is for new uses and gradual increases in consumption of lithium in its various forms.

Possible new uses include well-drilling muds, bleaches, light-metal alloys, propellants, fertilizers, food preservatives, cermets, oil additives, electrolyte of aluminum cells, reducing agents in production of refractory metals or organic compounds, and liquid metal heat transfer agents.

Further expansion and intensification of the research program both by lithium producers and other research groups are anticipated. Emphasis will be placed on development of new uses, but research on basic properties of lithium and its compounds and on improvement of mining and processing methods is expected.

Prices, already declining, may be further reduced by more efficient plants and processes and greater competition. All these factors should contribute to an expanded industrial application of lithium products.

The major immediate problem of the lithium industry is that production capacity exceeds commercial requirements. New markets and expansion of existing markets have not developed as rapidly as anticipated. This problem is further accentuated by the lack of statistical data on lithium minerals and compounds. This makes it difficult for industry and government to determine requirements, evaluate market potentialities, and to plan future action.

In all pegmatite operations, the major problems are mining and the efficient recovery and economic disposition of the maximum number of coproducts and by pro-

ucts. Lithium processing problems extend through all stages, from the mining to the manufacture of the end product compound. Recovery of lithium minerals from their various ores by known methods is inefficient when compared to recoveries of other minerals, and better recovery of lithium compounds from the various minerals is also needed.

There is a need to develop additional lithium reserves to supply the expanding industry on a long-range basis. Domestic reserves of other lithium minerals such as lepidolite, amblygonite and petalite are small in terms of current consumption and anticipated requirements.

REFERENCES

1. Broadhurst, Sam D. Lithium Resources of North Carolina. North Carolina Dept. of Conservation and Development, Div. of Min. Res., Inf. Circ. 16. 1956, 37pp.
2. Clarke, F., Zinner, Paul, and Others. Edison Spodumene Mine, Pennington County, S. Dak., Bureau of Mines Rept. of Investigations 4234, 1948, 23 pp.
3. Ferro, D. P., Franklin, J. W., and Cleaver, G. H. Lithium. *Eng. Min. Jour.*, [illegible], No. 9, September 1955, pp. 75-89.
4. Hatton, Walter M. Lithium Compounds in Porcelain Enamels. *Bull. Am. Ceram. Soc.*, *27*, No. 12, December 15, 1948, pp. 492-495.
5. Foote Mineral Co. Lithium in Modern Industry. Philadelphia, 1950, 25 pp.
6. Gale, W. A. Lithium from Searles Lake. *Chem. Ind.*, September 1945, pp. [illegible]-446.
7. Holder, R., Nielsen, R., and Herre M. Lithium and its Compounds. *Ind. Eng. Chem.*, *43*, No. 12, December 1951, pp. 2636-2646.
8. Hosler, T. L. The Tin-Spodumene Belt of the Carolinas. *Geol. Survey Bull.* [illegible]J, 1942, pp. 245-269.
9. Materials Advisory Board, National Research Council. Lithium. June 15, 1955, 17 pp.
10. Minneapolis Branch, Mining Division, Staff. Investigation of the Mateen Spodumene Deposit, Pennington County, S. Dak., Bureau of Mines Rept. of Investigations 4339, 1948, 20 pp.
11. Munson, G. A., and Erickson, K. L. Studies on the Flotation of Spodumene from the Edison Mine, Keystone, S. Dak., Bureau of Mines Rept. of Investigations 3892, 1946, 8 pp.
12. Norman, J., and Gieseke, E. Beneficiation of Spodumene Rock by Froth Flotation. *AIME Min. Technol.*, *4*, Tech. Pub. 1161, March 1940. 9 pp.
13. Norton, J. J., and Schlegel, D. H. Lithium Resources of North America. Geol. Survey Bull. 1027-G, 1956, 26 pp.
14. Osborg, Hans. Lithium, Theoretical Studies and Practical Applications. Electrochemical Soc., New York, 1935, 68 pp.
15. Schwartz, G. M. The Tin Mountain Spodumene Mine, Black Hills, S. Dak. *Econ. Geol.*, *25*, 1930, pp. 275-284
16. Soule, J. H. Exploration of Hardening Tantalum-Lithium Deposits, Taos County, N. M. Bureau of Mines Dept. of Investigations 3986, 1946, 10 pp.

REFRACTORY RESEARCH

(*Continued from page* 575)

evaluation, little of this type of testing has previously been attempted in the laboratory. In its place, simple tests devised for the evaluation of one known important feature have most often been substituted. Thus, the "oxiduction" test was used in the laboratory to learn the effects of cyclic reversal from oxidizing to reducing conditions. This test has aided in the development of products such as spinel-bonded periclase and forsterite which are resistant to the alternating changes in atmosphere that occur in the glass tank regenerators. However, the ultimate answer for refractories in this service had to be obtained, as always, through service trials where batch and fume carry-over temperature changes, etc., are also involved.

In a new approach to regenerator problems, a testing method based upon closer simulation of regen- 1959, a rotary hearth furnace was built as a tester for refractories which are subjected to repeated cycles of cooling and soaking accompanied by surrounding high temperatures. The refractories to be tested were placed on an annular hearth which rotated once every 30 or 60 minutes through a furnace and into the open air. In the cycle normally used, the furnace temperature was 2370°F. While this unit did not really match the conditions encountered in any glass furnace, the contrasting ability of various refractories to withstand the repetition of heating and cooling was quite surprising, as shown by two kinds of basic brick after 75 half-hour cycles. The type of cracking developed in one of them has also been observed in glass tank checker brick. However, this equipment had many salient limitations in its operation, and development was therefore started on still another test furnace (cover) believed to be more truly simulative of the conditions in glass tank regenerators. This unit has been designed to accommodate a setting of full-sized brick; it is gas-fired and can faithfully reproduce temperature cycles throughout the range encountered in normal service. The method for introduction of batch constituents has not yet been settled. These materials may be introduced into the flame through the burners, or placed in a suitable container inside the furnace where the flame would sweep across and carry the components down through the test brick settings. After the matter of straight temperature cycling is settled, changes will probably be made so that the chemistry of the atmosphere within the furnace can also be cycled. If successful, the result will be a piece of equipment which should give many indications of the conditions in selected glass furnace regenerators.

If in tests of this type, a particular refractory should hold up very well, the transition from laboratory to full-scale commercial installations should not be such a difficult job. Since the test furnace will hold a number of 9-in. bricks, it will be possible to test all sorts of experimental mixes on an accelerated basis.

Each glass tank operator has his own particular furnace problems, and each his own particular recipe for furnace construction. Since even small improvements in these individual recipes have so often been painfully won, it is not hard to understand that changes in furnace operation, composition, or type of refractory, are made very cautiously or only in the face of emergency. Nevertheless, everyone accepts the premise that to remain competitive, glass must be made more efficiently. This, in turn, means a trend toward furnaces which more severely tax refractories. To insure progress in the selection and use of refractories, few glass tanks should ever be rebuilt in exactly the same way; each rebuild should ordinarily incorporate modifications aimed at improvement.

AMERICAN SCIENTIFIC GLASSBLOWERS

(*Continued from page* 579)

the upper annealing temperature and softening point by means of torches, an oven, electrical resistor, or secondary radiator. Atmospheric pressure causes the tube to collapse around the mandrel, starting at the closed end where the heat has been first applied and proceeding along the length until the desired portion has been shrunk. The heating is then discontinued and the glass and mandrel are allowed to cool. The mandrel, having

Mathieson Soda Ash

For expert handling of your soda ash, Olin Mathieson has the experience and technical know-how to give you top-quality soda ash when, where and how you want it. Deliveries are made by rail, truck, or barge from our stocks at Saltville, Va., Lake Charles, La. or Wyandotte, Michigan. A detailed study of your handling problems will be made on request. Send for our free Soda Ash book. Write: OLIN MATHIESON, Baltimore 3, Md. 275

CHEMICALS DIVISION Olin

Reader Service Card: Circle No. 28

GANAGLAS OSCILLATING

BATCH CHARGER

The ONE Charger that performs the work of TWO

From 5 tons daily extraction to 120 tons daily extraction
This method of charging has distinct advantages since
IT CHARGES THE BATCH IN A FAN-LIKE PATTERN, SPREADING A BLANKET OF BATCH ACROSS THE WIDTH OF THE TANK FURNACE and will incorporate the following favorable effects

◆ Efficient and rapid melting ◆
◆ Improved glass quality ◆
◆ Reduction of temperature fluctuations ◆
◆ The clogging of regenerators minimized and, ◆ in general,
◆ Refractory life is considerably prolonged ◆ Economical to operate
◆ Easily installed in conventional type dog-houses, ◆ without the necessity of purchasing a large number of "special shapes"

We welcome the opportunity of submitting full details

GENERAL GLASS EQUIPMENT CO. INC. INTERNATIONAL, INC.
ATLANTIC CITY, NEW JERSEY

Reader Service Card: Circle No. 29

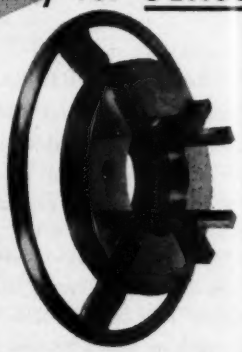
a greater thermal expansivity, is removed, leaving the vacuum-reformed tube.

Raw glass selected should have maximum freedom from defects—air lines, striae, crystallites, knots, stones, grooving, bow, etc. The glass should be clean and dry, and should have sharp edges removed to avoid scratching the mandrel. In reforming a glass, it is necessary to allow for the specific glass composition and its physical and chemical properties. For example, a neutral or oxidizing atmosphere might be used for a glass rich in PbO to avoid reduction. A reducing environment might be used with a specific aluminosiliciate glass to avoid reboil, and a sodium perborate solution treatment with a borosilicate glass to inhibit devitrification.

Mandrels can be made of a variety of metals and alloys. Thermal expansivity of the mandrel must be greater than that of the glass so that the glass can be removed on cooling, and the mandrel must have good high-temperature corrosion resistance to withstand the temperatures required for the particular glass. These mandrels may be of special shapes to produce various geometric cross sections, flutes, threads, and markings.

Defects in reformed glass can cause a high rejection rate unless very careful control is exercised. Cold crack can result when the reformed glass contacts a mandrel that has not been sufficiently preheated. Excess heat in the mandrel can cause sealing. Devitrification and reduction in certain glasses will occur in spite of favorable chemical environment under certain time/tem-

Designed Specifically for GLASS!



WESTCOTT
Glassworking
CHUCKS

Originally developed for use in manufacturing TV tubes, this self-centering Handwheel Actuated Chuck has proved its value on many other operations handled on glassworking lathes where ACCURACY, SIMPLICITY, and SPEED of operation are essential.

- **FAST OPERATION** Handwheel control. No wrench required.
- **LARGE CAPACITY** Outrigger type jaws.
- **ADAPTABLE TO ANY GLASSWORKING LATHE**

Send for FREE Circular

Users of WESTCOTT GLASSWORKING CHUCKS include:
- CORNING GLASS WORKS
- WESTINGHOUSE
- GENERAL ELECTRIC
- CALIFORNIA RESEARCH CORPORATION
- SYLVANIA ELECTRIC
- MACHLETT LABORATORIES

ONEIDA MACHINE TOOL CORPORATION
2000 E. WALNUT ST. ONEIDA, N. Y.
Manufacturers of Westcott Chucks and Glass Manufacturing Equipment

Reader Service Card: Circle No. 30

perature schedules. Excessive temperatures will cause "burns" in the glass. Vacuum-formed glass generally has an excessive amount of strain which may be sufficient to cause spontaneous breakage in heavy-walled glass if it is not relieved within the same day of fabrication.

INVENTIONS AND INVENTORS

(*Continued from page* 591)

Feeding and Forming

Apparatus for Making Glass Film. Patent No. 2,986,844. Filed July 13, 1959. Issued June 6, 1961. One sheet of drawings; not reproduced. Assigned to Emhart Manufacturing Co. by Edward K. Lane, Jr.

The apparatus is comprised of two oppositely disposed rotatable surfaces which are positioned closely adjacent to each other at one point. While the axes of the rotatable members may be parallel, it is preferred that the axes be inclined and that the surfaces be parallel and overlap each other.

A continuous supply of molten glass is deposited on, and in the space between, the oppositely disposed surfaces on the rotable members. The members are rotated in opposite directions at the same speed so that the oppositely disposed surfaces are moved in the same general direction at the point of adjacency. The diverseness of the axes of the rotatable members and the opposite rotation causes the surfaces to converge toward, and from, the point of adjacency. Inasmuch as the surfaces are rotated at the same speed, the only relative motion between the surfaces is laterally. The relative lateral movement between the oppositely disposed surfaces causes the molten glass to stretch into a thin sheet of film.

There were 7 claims and 11 references.

CLASSIFIED ADVERTISEMENTS

Help Wanted

PLANT ENGINEER

Retirement will create opportunity with progressive glass container manufacturer in Southern California. Extensive experience required in plant or maintenance, engineering and supervision of tank construction, operation and hot repairs. Submit complete résumé of experience and salary requirement. Confidential. Reply to Box No. 242, The Glass Industry, 55 West 42nd Street, New York 36, N.Y.

MANAGER OR ASSISTANT MANAGER: for engineering sales and development of activities listed in our ad this issue plus other new developments. Degree and considerable experience glass industry required. Must have organizing ability and managerial interest. Limited travel USA and abroad. Reply to Penberthy Electromelt Company, 4301 6th Ave. South, Seattle 8, Washington.

GLASS TECHNOLOGIST with some experience in batch and furnace operation. Large East Coast container plant has opening for qualified man. Please submit résumé of experience, education, and salary requirements in first letter. Reply to Box No. 243, The Glass Industry, 55 West 42nd Street, New York 36, N. Y.

Delos M. Palmer & Associates

Consulting Engineers
Mechanical, Electrical & Industrial
Designers of
Special Purpose Machinery
For The Glass Industry
Automation . . . Electronics

4401 JACKMAN ROAD TOLEDO 12, OHIO
Telephone: Greenwood 9-4453
Reader Service Card: Circle No. 31

EISLER Equipment
solves glass problems!

Since 1920, designers and builders of special machinery and equipment for the glass industry . . . Glass Lathes • Glass Cutters • Wet or Dry Silent Blast Torches • Cross Fires • Ribbon Fires • Gas and Oxygen Burners • Indexing Turntables • Sealing, Ampule and Bulb Blowing Machines, etc.
Call us now without obligation

Above: SPECIAL CROSSFIRES
Below: BLAST BURNERS

EISLER ENGINEERING CO., INC.
742 So. 13TH ST., NEWARK 3, N. J.
Charles Eisler, Jr.
President
Reader Service Card: Circle No. 32

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING ENGINEERS
FOR THE GLASS INDUSTRY

LANCASTER, OHIO U. S. A.

Reader Service Card: Circle No. 33

PEN ELECTRO

Service to the Glass Industry

- Electric Booster Melting
- Molybdenum Electrodes
- Tubing Diameter Gagers
- Glass Bath Pyrometers
- All Electric Furnaces
- Electric Forehearths
- Bubbler Systems
- Color Feeders

Write for descriptive literature

PENBERTHY ELECTROMELT CO.
4301 6th AVE. SOUTH
SEATTLE 8, WASHINGTON